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L. O. HOWARD, Entomologist and Chief of Bureau.

PAPERS ON INSECTS AFFECTING VEGETABLES.

I. THE HAWAIIAN BEET WEBWORM.
By H. O. MARSH, *Agent, Engaged in Sugar-Beet and Truck-Crop Insect Investigations.*

II. THE SOUTHERN BEET WEBWORM.
By F. H. CHITTENDEN, *In Charge of Truck-Crop and Stored Product Insect Investigations.*

III. THE IMPORTED CABBAGE WEBWORM.
By F. H. CHITTENDEN, *In Charge of Truck-Crop and Stored Product Insect Investigations,* and H. O. MARSH, *Agent.*

IV. A LITTLE-KNOWN CUTWORM.
By F. H. CHITTENDEN, *In Charge of Truck-Crop and Stored Product Insect Investigations.*

V. ARSENITE OF ZINC AND LEAD CHROMATE AS REMEDIES AGAINST THE COLORADO POTATO BEETLE.
By FRED A. JOHNSTON, *Entomological Assistant.*

VI. THE SUGAR-BEET WEBWORM.
By H. O. MARSH, *Entomological Assistant.*

VII. THE HORSE-RADISH WEBWORM.
By H. O. MARSH, *Entomological Assistant.*

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ERRATA.

Page 33, line 7, for *Agrostis* read *Agrotis*.

Page 72, line 14, for *scale like* read *scale-like*.

Page 76, last sentence, read, *In this garden the larvæ have evidently been prevented by a hymenopterous parasite from causing much damage, and at present no artificial control measures are necessary.*

U. S. D. A., B. E. Bul. 109, Part I. T. C. & S. P. I. I., November 6, 1911.

PAPERS ON INSECTS AFFECTING VEGETABLES.

THE HAWAIIAN BEET WEBWORM.

(*Hymenia fascialis* Cram.)

By H. O. Marsh,
Agent, engaged in Sugar-Beet and Truck-Crop Insect Investigations.

INTRODUCTORY.

During the latter half of 1910 the author was engaged in a study of insects affecting truck crops in the Hawaiian Islands. The enemies of beets and of the so-called spinach (*Amaranthus* sp.) were among the insects which were studied. The species injurious to these two crops had previously received very little study from an economic standpoint, and the necessity of such study was further enhanced by the fact that a land company was experimenting with sugar beets on the island of Lanai[1] with the intention of growing this crop on a large scale, if it should offer promise of becoming profitable.

In the vicinity of Honolulu, on the island of Oahu, vegetables are grown in commercial gardens, managed by Chinese or Japanese. In a general sense, these growers may be considered "good farmers" although they have little regard for the necessity of clean culture and seldom make any intelligent effort to combat insect pests or plant diseases. In the rare cases where an effort is made to cope with such troubles, the methods employed are extremely crude. Practically all cultivation is done by hand, except that occasionally the water buffalo is used for plowing the land before the crops are planted. From the Oriental point of view this plowing is considered sufficient if the surface of the ground is scratched to the depth of a few inches. The fertilizing material used is in liquid form. It is prepared by soaking stable manure or other refuse material in water and is applied directly about the plants.

Table beets and "spinach" are produced exclusively for the local market. These vegetables are grown in beds, in a peculiar manner, which Mr. E. M. Ehrhorn has aptly designated "the graveyard style." The beds, which are very often about 10 yards long by 1

[1] The sixth largest island of the group.

yard wide, are mounded up about 6 to 8 inches above the surrounding surface, the top is leveled, and the seeds are planted on these elevated plats, which have an appearance very suggestive of graves.

Although the climate is rather humid the normal rainfall, at Honolulu, is so light that irrigation is necessary to produce a crop. Practically all the gardens have an abundant supply of artesian water, but, owing to the manner in which the beds are elevated, it is impossible to run the water between the rows of plants, and as a result they have to be watered by hand. This is accomplished by dipping up the water in large watering cans and sprinkling it over the beds. It would seem that this slow and laborious method of irrigation could be eliminated if the beds were prepared in a more up-to-date manner.

The so-called spinach is not the plant which is recognized by that name in mainland markets, but is a species of Amaranthus. The leaves and stems of the young and tender plants, when properly cooked, make fairly palatable "greens."

FOOD PLANTS AND INJURY.

The most conspicuous enemy of this class of vegetables is the Hawaiian beet webworm (*Hymenia fascialis* Cram.). In the Hawaiian Islands the larvæ of this species include among their food plants table beets, sugar beets, stock beets (mangel-wurzels), several species of Amaranthus, Euxolus, purslane (*Portulaca oleracea*), cucumbers, and chenopodiaceous weeds. Among the wild food plants, Amaranthus is the favorite. These weeds grow in abundance along fences and in neglected spots, and it frequently happens that the plants are so completely stripped of foliage that large patches of them die. Cultivated Amaranthus is likewise severely damaged. Beets are a close second in attractiveness, and it is not unusual to see beds of this vegetable with nothing remaining of the foliage but the petioles. When infestation is very severe the plants are occasionally killed outright, and even when the larvæ are less abundant the infested beets are stunted in growth and injured in quality. Sugar beets are attacked as readily as the table variety. During the latter part of August, 1910, the author received some sugar beets from the experimental plats on Lanai, from which practically all the foliage had been stripped, and it was reported that all the beets in the plats were in a similar condition. This webworm is the most serious insect pest which menaces the production of sugar beets in Hawaii, and unless it is controlled it is unlikely that this crop can be profitably grown. Cucumbers are apparently only rarely attacked and the occasional larvæ which were found infesting this cucurbit were doubtless feeding on it because more attractive food was not available. Portulaca is commonly attacked but apparently is not so favored a food as Amaranthus or beets.

LIFE HISTORY AND HABITS.

All stages of this pest can be found throughout the year. The moths (fig. 1) are usually to be found in abundance among the foliage of Amaranthus, beets, or other low-growing plants. During the day they remain concealed, usually on the underside of the leaves, but when disturbed they fly readily. They are but rarely attracted by lights. The scale-like iridescent eggs (fig. 2, *a*) are almost invariably deposited on the underside of the leaves. They are placed singly, in pairs, or in rows of five or more. On beet leaves, the favorite place for depositing eggs is along the midrib and larger veins. As many as 40 eggs, which had been deposited in the field under normal conditions, were counted on a single beet leaf. The eggs have been ob-

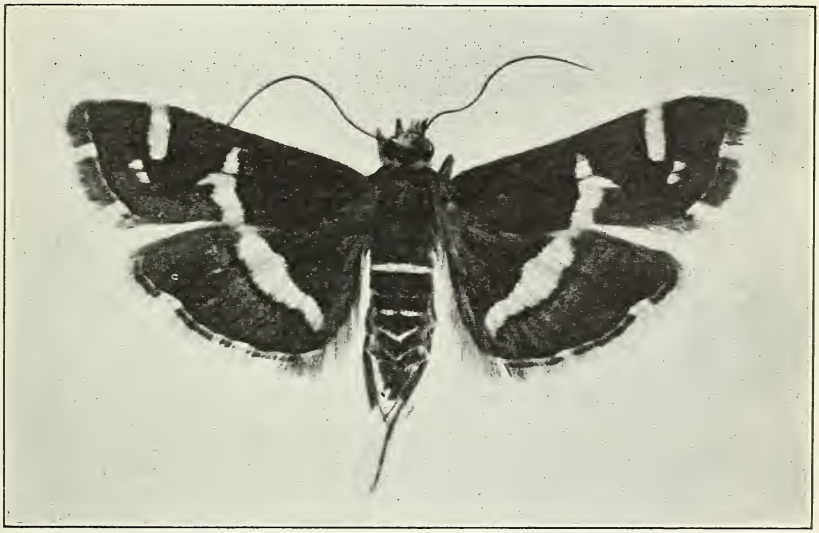

FIG. 1.—The Hawaiian beet webworn (*Hymenia fascialis*) : Female moth. Enlarged. (Original.)

served to hatch in 4 days. The young larvæ feed on the lower surface of the leaves. On beets, and probably on other plants, the larvæ, except when nearly mature, consume only this surface. This habit of remaining on the underside of the leaves, without eating through the upper epidermis, adds to the difficulty of successfully treating this pest with insecticides. (See larva and details, fig. 2, *b–e*.)

In some cases the larvæ spin light webs, under which they rest. This web-forming habit is not very pronounced, and it is not unusual to find hundreds of larvæ without any webs whatever.

Under normal conditions the larvæ reach maturity in from 9 to 13 days. They then leave the plants, burrow slightly beneath the surface, and form firm, compact, oblong cocoons of webbed-together

grains of earth. From the time of hatching until fully mature, the larvæ are pale green, but while engaged in constructing their cocoons (fig. 2, *h*), they change to a reddish pink. They usually pupate about 2 days after entering the soil, and the adults issue from 7 to 13 days later, thus completing a generation in from 22 to 31 days. (See pupa and details, fig. 2, *f*, *g*.)

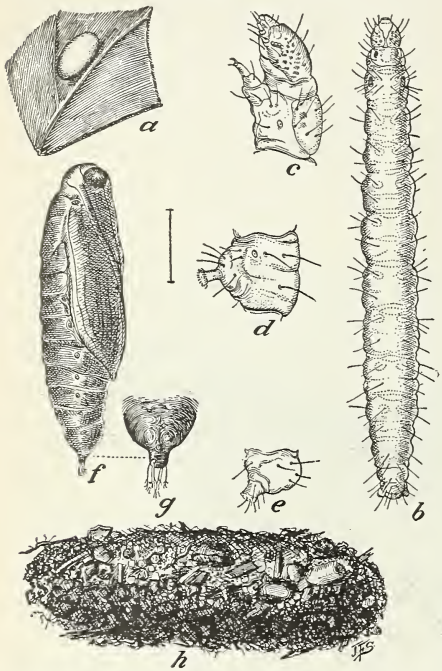

FIG. 2.—Hawaiian beet webworm: *a*, Egg on leaf; *b*, larva, dorsal view; *c*, larva, head and first thoracic segment; *d*, abdominal segment, lateral view; *e*, anal segment; *f*, pupa, lateral view; *g*, cremaster; *h*, cocoon. All enlarged. (Original.)

The climate of Hawaii is so equable that this pest is enabled to breed continuously, and it is possible that ten or twelve generations might be produced annually. Owing to the overlapping of broods and to the fact that eggs, larvæ, pupæ, and adults are to be found at almost any time, it is practically impossible to work out the number of generations for a given year from field observations alone.[1]

Beginning in July, 1910, and continuing past the middle of January, 1911, the author reared this species through six generations in the insectary. The records of five of these generations are given below. The actual first (July-August) generation was reared from larvæ which were collected in the field, and as the egg stage was not obtained the record is incomplete and is not included in this paper. For the sake of convenience the August-September generation is mentioned as the first, although, in reality, it was the second. The five following generations are in direct line of descent.

FIRST GENERATION.

August 20.—At this date four moths were collected in the field and confined in a cage.

August 25	First eggs deposited.
August 29	The eggs hatched.
September 7	First larvæ reached maturity.
September 9	First larvæ pupated.
September 16	First adults issued.

[1] It is not probable, however, that more than six generations can be produced successively, beginning with one pair of moths, since insects in general, in the writer's experience, always undergo a resting stage—sometimes two.—F. H. CHITTENDEN.

From the above record the stages are as follows:

	Days.
Egg stage	4
Larval stage	11
Pupal stage	7
Total	22

SECOND GENERATION.

September 16	Adults issued.
September 18	First eggs deposited.
September 22	The eggs hatched.
October 3	First larvæ reached maturity.
October 5	First larvæ pupated.
October 15	First adults issued.

From the above record the stages are as follows:

	Days.
Egg stage	4
Larval stage	13
Pupal stage	10
Total	27

THIRD GENERATION.

October 15	Adults issued.
October 17	First eggs deposited.
October 21	The eggs hatched.
November 1	First larvæ reached maturity.
November 3	First larvæ pupated.
November 12	First adults issued.
November 13	More adults issued.

From the above record the stages are as follows:

	Days.
Egg stage	4
Larval stage	13
Pupal stage	9
Total	26

Curiously enough the first moths, 10 in number, which issued November 12, failed to deposit any eggs, so the first eggs deposited by moths which issued the following day (Nov. 13) were retained to commence the succeeding generation.

FOURTH GENERATION.

November 13	Adults issued.
November 16	First eggs deposited.
November 20	The eggs hatched.
December 2	First larvæ reached maturity.
December 5	First larvæ pupated.
December 17	First adults issued.

From the above record the stages are as follows:

	Days.
Egg stage	4
Larval stage	15
Pupal stage	12
Total	31

FIFTH GENERATION.

December 17	Adults issued.
December 19	First eggs deposited.
December 23	The eggs hatched.
January 4	First larvæ reached maturity.
January 6	First larvæ pupated.
January 19	First adults issued.

From the above records the stages are as follows:

	Days.
Egg stage	4
Larval stage	14
Pupal stage	13
Total	31

These records were obtained in an open-air insectary at Honolulu. The moths were confined in open-wire cages, which contained an inch or more of moistened, sterilized soil. Beet or Amaranthus leaves, upon which the eggs were to be deposited, were placed in the cages and food was supplied the moths by putting in wads of absorbent cotton, which had been saturated in molasses and water. This food was evidently greatly relished. The moths were very "wild" and flew about very actively whenever the cages were approached. Copulation evidently took place at night, as during the several months that the species was kept under daily observation, in the insectary and field, no mating pairs were observed. Owing to the failure to obtain mating pairs and to the fact that it is difficult to distinguish the sexes when the moths are fluttering wildly about in the cages, no individual egg-laying records were obtained. In one case three newly emerged and unfertilized female moths were placed in a cage and supplied with molasses as food. They lived 10 days, and during this time deposited 300 eggs. Such a record is not conclusive, but it indicates that each female is capable of depositing at least 100 eggs. This is doubtless far short of the actual number of eggs that one female could deposit under normal conditions.

Temperatures at Honolulu during the time the species was reared.

Month.	Minimum temperature.	Maximum temperature.	Average mean temperature for entire month.
1910.	°F.	°F.	°F.
July	69	84	76.5
August	66	85	76.8
September	69	85	77.0
October	65	84	75.3
November	66	84	74.6
December	62	80	71.2
1911.			
January	58	79	70.0

NATURAL ENEMIES.

At various dates larvæ were collected in the field and confined in cages in the insectary. In this way three species of hymenopterous parasites were obtained. These were *Limnerium hawaiiense* Cram., *Chelonus blackburni* Cram., and *Cremastus hymeniæ* Vier.

L. hawaiiense was obtained in greatest numbers during August and September, while *C. blackburni* apparently became more abundant during December. *C. hymeniæ* was reared only in small numbers and at all times appeared to be more rare than the other species. No predaceous enemies were actually observed feeding on the Hymenia larvæ or pupæ, but on several occasions a species of wasp (*Polistes hebræus* Fab.) was seen buzzing about infested plants. During the warmer months this wasp and allied species are efficient enemies of the common cabbage worm (*Pontia rapæ* L.), and it is not improbable that they also occasionally kill Hymenia larvæ. On the whole, the natural enemies apparently do not reduce the number of Hymenia larvæ sufficiently to be of much practical value.

EXPERIMENTS WITH INSECTICIDES.

During the fall of 1910, an opportunity was taken to make some experiments against the Hymenia larvæ with insecticides. The experiments were as follows:

Experiment No. 1.—Paris green, 4 pounds, and lime, 4 pounds, in 100 gallons of water. September 1, three beds of table beets, each 10 yards in length and 1 yard wide, were sprayed with about 2 gallons of this mixture. The application was made with a portable, compressed-air sprayer, which was fitted with a short extension-rod elbow and a Vermorel type nozzle. The mixture was applied chiefly to the upper surface of the leaves and it adhered very well. The weather at the time of the application was hot and clear and without a breeze.

The following day all the larvæ were alive, except those on accasional leaves which were poisoned on the underside. Thirty-three

live larvæ were counted on the underside of one leaf. These beds were examined daily, and on September 7 it was concluded that the experiment was a failure, as the larvæ, except on the leaves which had been thoroughly sprayed on the underside, were unharmed. It was noted that on leaves which had been but partially sprayed on the underside the larvæ avoided the poisoned portion but continued to feed on the part which had been missed by the spray. The failure of this experiment was due to the habit the larvæ have of feeding on the underside of the leaves, without eating through the upper epidermis. The mixture used in this experiment burned the partly consumed leaves slightly but caused no extensive injury.

Experiment No. 2.—Paris green, 2 pounds, and whale-oil soap, 8 pounds, in 100 gallons of water. September 7, three beds of table beets, each 10 yards in length and 1 yard wide, were sprayed with about 3 gallons of this mixture. The same apparatus was used as in experiment No. 1. A particular effort was made to wet the under surface of the leaves thoroughly. The mixture adhered perfectly and an extremely even distribution of the poison was obtained. The weather was hot and clear.

The following day nearly all the larvæ were dead and the few individuals which remained alive appeared very sick. September 10, the beets were free of larvæ and the foliage showed no burning by the spray mixture. Two weeks later the sprayed plants were still free of larvæ, while beets in adjoining (check) beds were badly infested. This experiment plainly demonstrates that if the spray is applied properly, i. e., to the underside of the leaves, it can be depended on to control this pest.

In addition to the experiments with Paris green, a few preliminary and somewhat inconclusive tests were made with arsenate of lead, lead chromate, and lime-sulphur solution. For the sake of convenience these will be classed as experiments.

Experiment No. 3.—Arsenate of lead, 1½ ounces, and molasses, 1 quart, in 1½ gallons of water. This mixture was experimented with as a poisoned bait for the melon fly (*Dacus cucurbitæ* Coq.), and was not originally intended for use against the Hawaiian beet webworm. September 7, a patch of Amaranthus, badly infested by larvæ varying in size from those recently hatched to others nearly mature, was sprayed with some of this mixture. The spray was applied very thoroughly to the upper and lower surfaces of the leaves with the same apparatus as used in experiment No. 1. The following day the larvæ were unharmed. The leaves showed a good even coat of the arsenate. The sprayed plants were kept under daily observation until September 13, at which date they were destroyed. On the 9th and 10th of September it was noted that the larvæ were growing nicely and appeared to relish the poison-coated leaves.

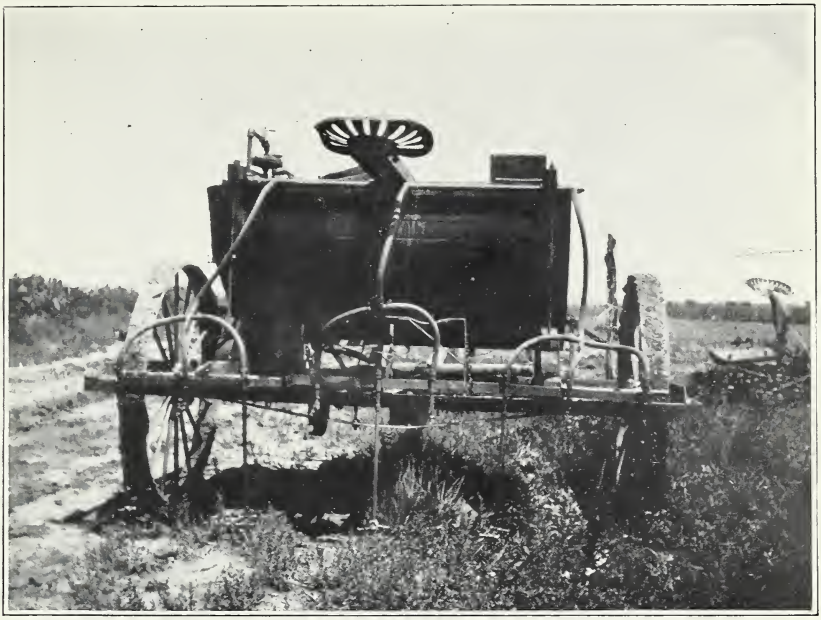

FIG. 1.—GEARED TRACTION SPRAYER SUITABLE FOR THE TREATMENT OF SUGAR BEETS AGAINST THE HAWAIIAN BEET WEBWORM. (ORIGINAL.)

FIG. 2.—GEARED TRACTION SPRAYER IN OPERATION IN SUGAR-BEET FIELD AGAINST THE HAWAIIAN BEET WEBWORM. (ORIGINAL.)

September 12, all the larvæ which had not matured were still feeding and showed no ill effects from their diet of arsenate of lead and Amaranthus leaves. The spray mixture caused no injury to the foliage.

In this test a standard grade of arsenate of lead was used at the rate of 6¼ pounds in 100 gallons of water, and it is difficult to understand why it failed to kill the tender Hymenia larvæ. Of course, such a test as this can not be considered conclusive, but it would indicate that less effective results would be obtained with arsenate of lead than with Paris green.

Experiment No. 4.—Lime-sulphur solution, 1 gallon, in 15 gallons of water. November 1, a few infested beets were sprayed with a small quantity of this solution. A thorough application was made to the upper surface and underside of the leaves with an atomizer. Larvæ which were drenched with the solution appeared to die promptly. The weather was hot and clear at the time of the application. Two days later the larvæ had been reduced somewhat in numbers but there were still plenty of living specimens present. Some of the leaves were severely burned. November 5, the coat of lime was still very good. The larvæ were feeding on the coated leaves and were apparently unharmed. This solution apparently killed only the larvæ which were thoroughly drenched at the time of the application. The beet foliage was severely burned, and on the whole the results were not promising.

Experiment No. 5.—Lead chromate, 2 ounces, in 8 gallons of water. December 16, a few infested beets were sprayed with a small quantity of this mixture. The application was made to the upper and lower surfaces of the leaves with an atomizer. The mixture appeared as a yellow coating on the leaves and adhered very well. The weather was hot and clear. Three days later the larvæ were still alive, but had ceased feeding, and were clinging to the leaves in a listless manner. During the following two or three days they dropped to the ground and died. The sprayed foliage showed no burning. It is not possible to form a definite conclusion from this meager test, but it indicates that lead chromate at this strength is very slow in its killing effects.

In another similar test lead chromate was used on beets at the rate of 2 ounces in 4 gallons of water. Unfortunately an illness of the author prevented the making of observations as to the effect of this strength on the larvæ. Ten days after the application it was noted that two heavy rains had failed to wash the coat of poison from the leaves and that no burning had resulted. It is evident that this new insecticide has some good points, and it should be given a thorough trial.

The results of the experiments may be summarized as follows:

Experiments with insecticides.

Experiment No.	Date.	Insecticide used.	Effect on larvæ.	Injury to foliage.	Remarks.
1	1910 Sept. 1	Paris green, 4 pounds, and lime, 4 pounds, in 100 gallons of water.	Ineffective....	Slight...	The poor results were due to the poison being applied to the upper surface of beet leaves where the larvæ failed to reach it.
2	Sept. 7	Paris green, 2 pounds, and whale-oil soap, 8 pounds, in 100 gallons of water.	Absolutely effective.	None....	Spray applied properly to the under surface of beet leaves.
3	...do.....	Arsenate of lead, 1½ ounces, and molasses, 1 quart, in 1½ gallons of water.	Ineffective....	...do.....	Applied to the upper and lower surface of Amaranthus leaves. There is no apparent reason for its failure to kill the larvæ.
4	Nov. 1	Lime-sulphur solution, 1 gallon, in 15 gallons of water.	.....do.....	Severe..	Applied to beet leaves. A few larvæ were killed by contact with the solution.
5	Dec. 16	Lead chromate, 2 ounces, in 8 gallons of water.	Possibly effective.	None....	Applied to beet leaves. The poison was very slow in its killing effect.

It will be seen from the record of experiment No. 2 that this webworm can be effectively controlled on beets with Paris green. When this poison is applied at the rate of 2 pounds in 100 gallons of water it will not burn beet foliage and in this formula it is better to omit lime and use whale-oil soap. The soap serves as an effective adhesive agent and when it is used the poison is very evenly distributed over the leaf surface.

As "spinach" is used as food by human beings while the plants are still young and tender, it is obvious that it would be unsafe to spray this crop with an arsenical. Instead of an arsenical it is recommended that the following nicotine-soap combination be used on spinach:

Nicotine sulphate	1 fluid ounce.
Whale-oil soap	4 ounces.
Water	4 gallons.

This formula was successfully used by the author at Honolulu, against the common cabbage worm (*Pontia rapæ* Linn.), the larva of the diamond-back moth (*Plutella maculipennis* Curtis), a looper (*Autographa precationis* Guen.), and the beet army worm (*Caradrina exigua* Hbn.). It has also been used effectively against several species of aphides or plant-lice and thrips. Although this formula has not been actually tested on Hymenia larvæ, there is no reason to believe that it would not prove entirely effective.

For treating moderate-sized plats in gardens a portable compressed-air sprayer or a bucket pump will give good results. The sprayer should be fitted with a short extension rod, an elbow, and a nozzle of the Vermorel type, which will deliver a fine, mist-like

spray. The elbow makes it possible to coat the underside of the leaves thoroughly. It is essential to bear in mind that, unless this surface of the foliage is thoroughly covered with the poison, the spraying will be ineffective. In the gardens about Honolulu, the difficulty of spraying the lower surface of the leaves is greatly increased by the closeness with which beets are planted in the mounded-up beds. If the method of planting were modified so that the plants were grown in slightly separated rows, it would simplify the matter of spraying.

It is evident that if sugar beets are to become a profitable crop in the Hawaiian Islands it will be necessary to spray them to prevent the ravages of this pest. For spraying large areas, such as fields of sugar beets, it is better to use a large geared or power sprayer. In some experiments which the author conducted on sugar beets in Colorado, against a somewhat similar species, the sugar-beet webworm (*Loxostege sticticalis* L.), ordinary barrel sprayers and geared sprayers, of 125 gallons capacity, were successfully used. With the nozzles arranged as in the accompanying illustration (Plate I, figs. 1, 2), it is an easy matter to spray thoroughly the underside of the leaves, if a pressure of 80 to 120 pounds is maintained.

DESCRIPTIONS OF THE EARLIER STAGES.

By H. G. Dyar, Ph. D.

The egg.—Uniformly elliptical, strongly flattened on the upper and lower sides, smooth, minutely granular; white (in alcohol). Size 0.6 by 0.4 by 0.25 mm.

Laid singly on the underside of the leaf near a vein.

Larva, stage 1.—Head rounded, not much higher than wide, slightly notched at vertex; smooth, shining testaceous whitish, with four large, black, pigmented ocelli close together in a semicircle, setæ rather coarse, pale, those next the ocelli darker. Width, about 0.25 mm. Body cylindrical, slender, uniform, whitish or colorless (in alcohol). Setæ coarse, from small concolorous tubercles, i and ii nearly in line with some coarse skin spinules near them; iv and v superposed, approximate; vi wanting; vii of three setæ at the leg base. Legs long, slender, normal.

The intermediate stages are not complete in the material. In all the larva is whitish throughout, marked only with a subdorsal black speck on joints 2 and 3.

Larva, last stage.—Head rounded, higher than wide, notched on vertex, clypeus high, reaching vertical notch; whitish, with brown freckles on the vertices of the lobes, cut by a central space devoid of these spots; five pigmented ocelli in a semicircle and one colorless one behind. Width, 1.2 mm. Body cylindrical, slender, uniform, the segments irregularly annulate; abdominal feet slender, cylindrical, the plantæ circularly expanded, the crochets in two-thirds of a circle, the open space on the outside; setæ fine, from concolorous invisible

tubercles, i and ii in line, iv and v approximate, superposed, iii and vi normal, vii of three separated setæ; joint 2 with six setæ on the shield in two rows, the shield concolorous; two setæ each for the prespiracular and subventral tubercles; joint 3 with iia and iib in line, iii separate, iv and v approximate, vi free. Color whitish, a long brown patch at the edge of the shield on joint 2 and over tubercles iia and iib on joint 3. Spiracles elliptical, those of joint 12 larger than the others.

The cocoon.—The cocoon is composed of silk with fragments of extraneous substances attached to the outside. Elliptical in shape, simple.

The pupa.—Of the obtected type; pale brown, the eyes dark. Cremaster square and flat, with a row of long, slender, terminal pale spines with hooked tips. Surface smooth, without sculpture. Size 10 by 2.5 mm.

APPENDIX.

By F. H. Chittenden, Sc. D.

Owing to the fact that Mr. Marsh's report on the Hawaiian beet webworm (*Hymenia fascialis* Cram.) was completed at Rocky Ford, Colo., he had no facilities for looking up the literature on the species. Moreover, it was thought advisable, owing to the difficulty of describing the earlier stages in alcohol, that a technical description be made by a specialist, hence this latter work was kindly furnished by Dr. Dyar, while the writer has compiled the description and synonymy of the species and outlined its distribution, history, and bibliography. In the preparation of the bibliography, Mr. Thomas H. Jones assisted, while the photograph of the moth was prepared by Mr. C. H. Popenoe, and the drawing of the immature stages by Mr. J. F. Strauss.

Much has been written of this species in a technical way, but practically nothing has been published of importance, to the writer's knowledge, in regard to the biology of the insect, or description of its earlier stages. Hence the notes which Mr. Marsh has furnished are of great value, especially as he treats the insect in detail from the standpoint of its occurrence and injuries in Hawaii, and has also performed valuable experiments in the line of remedial measures. It should be added that this species, since it occurs throughout the Gulf region west to California, is apt to be troublesome at any time.

DESCRIPTION AND SYNONYMY.

Hymenia fascialis was first described in the year 1782 by Cramer. The following is the synonymy accorded by Dr. Dyar in his list of North American Lepidoptera, published in 1902.

fascialis Cramer, Pap. Exot., iv, 236, 1782, syn.
angustalis Fabricus, Mant. Ins., ii, 222, 1787.
recurvalis Fabricus, Ent. Syst., iii, 2,237, 1794.
diffascialis Hübner, Verz. bek. Schmett., 361, 1826.
albifascialis Boisduval, Faun. Ent. Mad., 119, 1834.

The species has also been placed in the genera Zinckenia and Spoladea.

The following is a somewhat free translation from Cramer's original description in French:

FIG. O—*Fascialis*.—The white band and the spots on the black ground of this little moth, of which the two surfaces of the wings carry the same colors, are of a mother-of-pearl luster. The antennæ are filiform, the feet very long and slender, similar to all those which belong properly to the so-called family *Phal.* [*æna*] *Pyralis*. Monsieur M. Houttium has received it from Japan.

On the same page, as throughout the work, a similar description is furnished in Holland Dutch.

The reference to the illustration is Volume IV, of the same work, page 398, figure O.

The synonymy which follows is in accordance with Moore:

Phalæna recurvalis Fabricius, Syst. Ent., p. 407 (1775); Ent. Syst., iii, 2, p. 237 (1794).

Zinckenia recurvalis Zeller, Lep. Micro. Caffr. Kongl. Vet. Akad. Handl., p. 55 (1853); Lederer, Pyral. Wien. Ent. Mon., vii, p. 437 (1863); Snellen, Tijd. voor Ent., 1872, p. 95; Meyrick, Tr. Ent. Soc. Lond., 1884, p. 308.

Spoladea recurvalis Guenée, Delt. et Pyral., p. 225, pl. 8, fig. 5 (1854).

Hymenia recurvalis Walker, Cat. Lep. Het. B. M., xvii, p. 396 (1859).

Phalena fascialis Cramer, Pap. Exot., iv, pl. 398, fig. o (1782). Stoll, id., v, pl. 36, fig. 13 (1791).

Phalæna angustalis Fabricius, Mant. Ins., p. 309 (1787).

Hymenia diffascialis Hübner, Verz. bek. Schmett., 361 (1825–7).

Hydrocampa albifascialis Boisduval, Faun. Ent. Madag. Lep., p. 119, pl. 16, fig. 1 (1834).

?Phalæna nigrella Linnæus, Syst. Nat., Ed. 13, iii, App., p. 225.

DESCRIPTION OF THE GENUS.

The genus Hymenia is defined as follows:

Forewing rather narrow, triangular; cell more than half the length; first subcostal at one-fifth before end of the cell, third bifid, fifth straight from end of cell; discocellular slightly concave, radials from the ends; middle median very close to end of cell, lower at nearly one-third; hindwing short, rather broad, apex convex, exterior margin convex in the middle; cell two-fifths the length; subcostals from end; discocellular obliquely concave, radial from lower end; two upper medians from end of cell, lower at one-third. Body moderately slender; labial palpi ascending, slightly curved, reaching level of the eyes, second joint laxly squamous, broadest at the base, third joint small, slender, pointed; maxillary palpi slender; antennæ setaceous, basal joint nodular; legs slender, smooth, spurs long, hind spurs equal. (Moore).

DESCRIPTION OF THE SPECIES.

The species is described as follows:

Dark vinaceous-brown; in some lights olivescent greyish-brown; forewing with a short blackish-bordered white band from the costa before the apex, below and exterior to which are three small inwardly curved superposed spots.

which approach a dentate transverse white band extending from upper end of the cell to the posterior margin, this band being continued across the hindwing to near anal angle. Cilia with an interrupted brown inner line, alternated with white on forewing, entirely white on hindwing, bands on abdomen white, collar, front of head, base of palpi, and legs yellowish; tip of palpi and bands on forelegs blackish.

Expanse seven-tenths to nine-tenths inch. (Moore.)

DISTRIBUTION.

In Dr. Dyar's list the distribution accorded this species includes the United States, South America, southern Europe, South Africa, and Australia. There is also a record of this species occuring in India.

Cramer's type was from Japan. Hampton states that its habitat comprises "Neotropical and Ethiopian regions"; Palæarctic Asia from Syria to Japan; the whole oriential and Australian regions.

In the United States National Museum this species is represented by specimens from Key West, Fla. (Evermann); Miami, Fla. (Barnes); Jamaica, Dallas County, Ala. (Trelease); and Port au Prince, Haiti. To make this list more complete we should add California and Hawaii, the islands of Madagascar, Bourbon (Reunion Id.), and Mauritius.

From the above it will be noted that this species is evidently of tropical origin, that it has been well disseminated nearly around the world, but that it is still confined to tropical, semitropical, and temperate climates. In the United States it probably has a larger range than above indicated. It at least ranges through the entire Gulf region to California.

HISTORY.

As has previously been stated, the species was first described by Pierre Cramer (1), who figured and described the moth, the description being in both French and Dutch, appearing in 1782. The type specimen was from Japan. In 1884–1887 Moore (2) furnished a technical description, with complete bibliography, which has been transcribed in previous pages. Following this, in 1900, Mr. Edward Barlow made mention of injuries by the larvæ to *Amaranthus mangostanus*, a pot herb in India, quoting Moore's synonymy and description. In 1907 Mr. W. W. Froggatt (6) stated that this little moth was common about Sydney, Australia, and that the larvæ were sometimes destructive to salt-brush hedges. Two years later (1909) Mr. O. H. Swezey (7) stated that the larva was fed on Euxolus, portulaca, garden beet, coxcomb, other amarantaceous plants, and on chenopodiaceous weeds. The same year Messrs. Lefroy and Howlett (8) published a short note on this species, stating that the larva attacked cultivated amaranthus, beet root, maize, and "other garden plants."

BIBLIOGRAPHY.

1. Cramer, Pierre.—Papillons Exotiques, pt. IV, p. 236, pl. 398, fig. 0, 1782.

   Original description in French and Dutch. Colored figure of adult. Type from Japan.

2. Moore, F.—The Lepidoptera of Ceylon, vol. III, pp. 293, 294, 1884–1887.

   Technical description with complete bibliography.

3. Barlow, Edward.—Ind. Mus. Notes, vol. 4, no. 1, pp. 16 and 17, pl. 11, fig. 5, 1900.

   Mentioned as *recurvalis*. Injurious to *Amaranthus mangostanus* L., a "pot herb" of India. Synonyms and description after Moore. Localities of specimens in Indian Museum.

4. Dyar, H. G.—Bul. 52, U. S. Nat. Mus., p. 373, 1902.

   Listed with synonymy and distribution.

5. Holland, W. J.—The Moth Book, p. 392, pl. 47, fig. 28, 1909.

   Mentioned as *Zinckenia fascialis;* synonymy; said to be found all over the temperate and subtropical regions of both hemispheres and to be common in southern portions of United States.

6. Froggatt, W. W.—Austr. Ins., p. 270, Sydney, 1907.

   "Common little moth about Sydney." Larvæ sometimes destructive to salt-bush hedges. Mentioned as *Zinckenia recurvalis*.

7. Swezey, O. H.—Proc. Haw. Ent. Soc., vol. 2, no. 3, p. 136, 1909.

   Mentioned as *recurvalis*. Said to feed on Euxolus portulaca, garden beet, cockscomb, other amarantaceous plants, and on chenopodiaceous weeds.

8. Lefroy, H. M., and Howlett, F. M.—Ind. Ins. Life, p. 516, 1909.

   Short note. Cultivated Amaranthus, beet-root, maize, and "other garden plants" mentioned as hosts.

9. Viereck, H. L.—Proc. U. S. Nat. Mus., vol. 40, p. 189, 1911.

   Description of a parasite, *Cremastus hymeniæ* n. sp., reared from this species at Oahu, Hawaii.

10. Marsh, H. O.—Bien. Rept. Bd. Agr. and Forestry. Hawaii (1910), p. 157, 1911.

    Short note. Paris green mentioned as an effective remedy.

PAPERS ON INSECTS AFFECTING VEGETABLES.

THE SOUTHERN BEET WEBWORM.

(*Pachyzancla bipunctalis* Fab.)

By F. H. Chittenden, Sc. D.,
In Charge of Truck Crop and Stored Product Insect Investigations.

INJURIOUS OCCURRENCES AND NOTES ON HABITS.

On September 24, 1906, the Bureau of Entomology obtained from Mr. F. W. Roeding, Wichita Falls, Tex., the larvæ, pupæ, and adults of the pyralid moth *Pachyzancla bipunctalis* Fab., which had been found operating on foliage of table beets in that vicinity. One larva transformed to pupa on September 25, and the adult issued October 3, the pupal period thus having occupied eight days in an average temperature of about 70° F. From this lot imagos continued to issue until October 2, and a larva matured October 10 which would have produced an imago about October 30.

During October, 1907, Mr. H. M. Russell observed larvæ at Dade City, Fla., on beet tops from 6 to 8 inches high, "webbing up" the leaves with the edges of the leaves folded together or joining two or more leaves to make a nest in which to hide. From this concealment they emerge and eat the leaf cells composing it, usually leaving the leaf skeletonized or very thin. In these nest-forming and leaf-eating habits the insect resembles the related Pyraustidæ. Mr. E. B. Embry, located at Dade City, Fla., stated that the larvæ of this species had injured the foliage of small beets so badly as to reduce his crop about 50 per cent. As late in the season as November 29, the webworm larvæ were found in another locality at Dade City, some of which showed parasitism. In January, 1909, larvæ were observed attacking beets at Boynton, Fla., and in March, beets at Miami, Fla.

From webworm material obtained October 18, one pupated October 23, and the moth issued November 8. Another larva pupated November 6 and the adult issued on November 21, thus indicating a pupal period covering from 15 to 16 days, in the latitude of Washington, D. C. In another case the pupal stage lasted from December 31 to January 22, or a total period of 23 days. The temperature at Washington was moderately cold.

This species was observed in 1908, by Mr. D. K. McMillan, at Brownsville, Tex., working in colonies on the foliage of pigweed (*Amaranthus retroflexus*), and on spiny amaranth (*A. spinosus*), the larvæ webbing and folding the foliage in the previously described manner. The colonies in question came under observation on April 30, May 14, June 15, and November 5, 1908. Mr. McMillan also observed the larvæ in large numbers during the spring of that year, working on "spinach" in the Rio Grande Valley and on beet foliage at Brownsville.

On May 28, 1909, Messrs. McMillan and H. O. Marsh observed these larvæ at Brownsville, Tex., embedded in the leaves of *Amaranthus retroflexus*. The larvæ were not in abundance at that time, doubtless owing to the extensive parasitism in May and June of the preceding year (1908). This was the first observed appearance of the insect that year.

During the same year this species twice came under the observation of Mr. H. M. Russell, in the first instance at Boynton, Fla., on January 27, 1909, when the larvæ were found in great abundance on the foliage of table beets. They had nearly stripped an early planting and were also abundant on a later planting. In many cases the larvæ were present on the underside of the leaves and had drawn the leaf into a fold, inside of which they were concealed. In other cases the larvæ were concealed by the folding up of the leaf from the edge, while in further instances two beet leaves were fastened together in such a manner that the larvæ were concealed between them. In feeding, the leaf substance is usually entirely eaten through to the surface, the leaf skeleton alone being left. The larvæ void a very soft excrement which produces a filthy condition of the leaves. Later on, March 3, the larvæ were found by Mr. Russell in fair abundance on beet tops at Cutler, Fla., and still later at Miami, Fla., on *Amaranthus retroflexus*.

Beginning with March, 1909, parasitic cocoons were seen on the leaves of beets, and early parasitism was indicated by the presence of parasitic cocoons on other food plants. Amaranth is abundant along the edges of many fields in southern Florida, and it is impossible to destroy it to a very great extent, as it grows luxuriantly on hundreds of acres of unclaimed lands. It costs from $15 to $75 an acre to clear hammock for planting. Perhaps, therefore, it is just as well to allow the amaranth to remain and to spray the weeds as a means of keeping this pest in check. There is little doubt that unless the parasites continue their good work the species is likely to cause a serious outbreak at almost any time in the future.

Of one lot of material received at Washington, D. C., the larvæ of which were nearly mature, it was noticed that they began to "spin up" preparatory to pupation on May 7; the following day some of

the larvæ had pupated and by May 20 the adults had commenced to issue, thus giving a total period for the pupal stage of about 12 days. The moths were placed in a large cage with a growing beet and at the end of the week all had died.

In other sendings of material the moths were observed to issue on May 25, June 3, and July 9.

The length of the egg stage was not ascertained, but it may be safely stated to be approximately 6 or 7 days, in moderate or warm weather. From eggs laid on June 5 and 6 the adults developed July 3, giving a total life cycle of 28 days, or 4 weeks, in hot weather, which will be about the minimum for the species. Assuming that

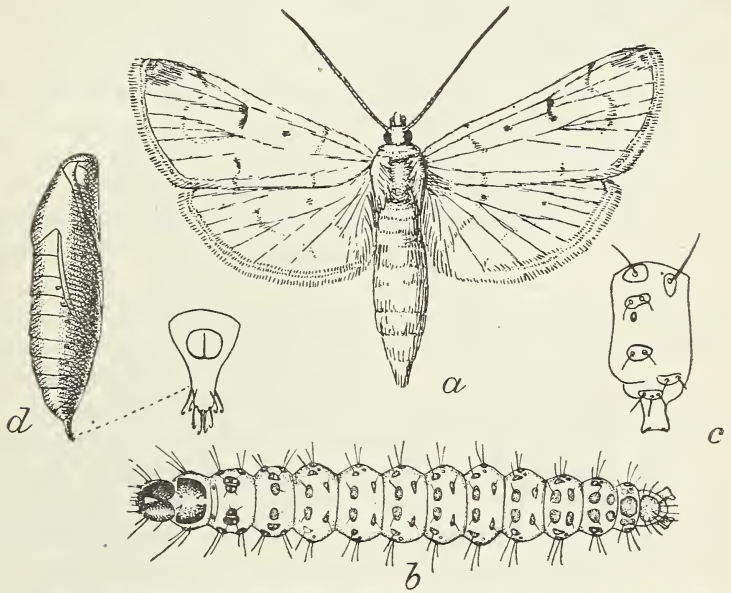

FIG. 3.—Southern beet webworm (*Pachyzancla bipunctalis*): *a*, Moth; *b*, larva; *c*, lateral view of first proleg and abdominal segment of larva; *d*, pupa, with cremaster showing location of hooks at right. *a*, *b*, *d*, About three times natural size. (Original.)

from 5 to 7 days is occupied by the egg stage, and approximately the same number of days for the pupal period in hot weather, the larval period would be approximately from 14 to 18 days. At least four generations are indicated for this species, and it is possible that there are more, but there are no positive data on record on this point.

DESCRIPTIVE.

The moth.—The moth in color varies from buff to very pale yellowish gray. The wings are slender and the antennæ long. In the pale forms the wings are nearly transparent, and the surface is rather iridescent purplish. The wing pattern of the pale individuals is faint, much more so than the illustration (fig. 3, *a*) would appear to indicate,

but is a little more definite in the dark forms. Near the anterior margin of the forewings there are three rather conspicuous black dots, one near the middle and one each side. The underside of the wings is paler and somewhat similar to the upper. The eyes are dark brown, nearly black. The abdomen is darker than the wings, and there are two black spots on the anterior margin of the third abdominal segment. The legs are long and slender. The total length of the body is less than one-half inch (12 mm.) and the wing expanse is about 1 inch (22 to 26 mm.).

The egg.—The egg is of irregular, short, oval outline, and considerably flattened upon the surface on which it is deposited. The color is pale yellowish, which looks green, owing to its semitransparence, permitting the color of the leaf to show through. The surface is finely reticulated, and under a high-power microscope is seen to be composed of minute, very irregular, moderately depressed areas, chiefly hexagonal and pentagonal in outline. The surface is rather strongly iridescent and glistens, presenting the appearance of a fish scale in miniature. Length, 0.6 mm.; width, 0.45 mm.

Eggs obtained in confinement, May 26, were deposited singly on the underside of beet leaves. Mr. Marsh also observed the eggs on the underside of amaranth leaves at Brownsville, Tex., June 22, 1909.

The larva.—The larva (fig. 3, *b*, *c*) is slender, cylindrical, and in the arrangement of the piliferous tubercles resembles *Loxostege similalis* Guen. and *L. obliteralis* Walk. The tubercles are not conspicuous in living specimens, but become prominent in preserved material. The color of the larva is dark, dirty green, with dark, mottled brown-and-black, or nearly black, head and thoracic plate, the latter widely separated at the middle. The dorsal piliferous tubercles are large and black, the two pairs being closely jointed. The remaining tubercles are large and infuscated, the dorsal ones transverse and arranged in two pairs, one pair on each segment. The tubercles of the last segment form a central plate, with a lateral one each side, in front of the larger anal plate. When boiled for preservation the larva becomes perfectly white, bringing into prominence the rings of tubercles which completely encircle each segment. The length of the larva when full grown is about three-fourths of an inch (19–20 mm.), and the width $\frac{3}{32}$ to $\frac{1}{8}$ of an inch (2.5–3 mm).

The pupa.—The pupa (fig. 3, *d*) is mahogany-brown, moderately slender, with the anterior extremity rounded, and the posterior prolonged into a bill-shaped cremaster, armed at the end with four very fine hooks, one lateral and two apical pairs, their tips strongly recurved. The abdominal segments are without spines. The length is about two-fifths of an inch (10 mm.).

The species is a pyralid and is placed in our lists next to *Loxostege*. It bears some resemblance to *Loxostege similalis*, but is considerably larger.

DISTRIBUTION.

This is without doubt a species of tropical origin and inclined to be cosmopolitan in any country suited to it climatologically. We have in the National Museum collections material from Pernambuco, Bonito Province, Brazil, as well as from Georgia, Texas, Florida, and the District of Columbia. It is recorded also from the West Indies and South Africa.

HISTORICAL AND BIOLOGICAL NOTES.

This beet webworm was first described as *"Phalæna 2-punctalis,"* in 1794.[1] In the year 1880 the larva was observed feeding upon cauliflower at Savannah, Ga., where it was stated to be very destructive. In consequence it was given the name of "Cauliflower botis." [2] It was also noticed that it fed on ragweed (Ambrosia), which is probably the original food plant, cauliflower being an acquired one, and perhaps not a food plant under normal conditions. The following year it was again noticed at Savannah, Ga., on pigweed, the larvæ webbing the leaves together and destroying many plants. Nothing further seems to have been recorded of its habits.

NATURAL ENEMIES.

Phorocera erecta Coq., a tachina fly, was reared from this species in September, 1906. This parasite has been reared from the related *Loxostege similalis*, at Victoria, Tex.

Amorphota sp. near *orgyiæ*, an ichneumonid parasite, was reared January 15–29, 1908, from *Pachyzancla bipunctalis*, obtained from Dade City, Fla., in October and December of the preceding year. A single female [3] before the writer measures 8 mm. in length and is opaque black, with castaneous abdomen and middle and posterior legs. The fore legs, and the tibiæ and tarsi on the middle pair of legs are light yellow, as is also the first joint of the antenna, the remainder of the antenna being black.

Bracon sp., a small blackish species of this genus,[4] was reared from this host at Brownsville, Tex., November 21, 1908.

ASSOCIATED INSECTS.

In addition to the parasitic natural enemies of this species which have been mentioned, some interesting species have been reared. Prominent among these is a moth of the same family and with somewhat similar habits, known as the Hawaiian beet webworm [5] (*Hymenia* [*Zinckenia*] *fascialis* Cram.). It was reared by Mr. H. M. Rus-

[1] Fabricius, Entomologia Systematica, vol. 3, pt. 2, p. 232, 1794.
[2] Botis repetitalis Grote, n. sp., Comstock, J. H.—Rept. U. S. Dept. Agr. for 1880, p. 270, 1881.
[3] Chttn. No. 303^{01}.
[4] Chttn. No. 1064^{01}.
[5] Bul. 109, Part I, Bur. Ent., U. S. Dept. Agr., 1911.

sell, at Cutler, Fla., March 23–29, 1909. It is interesting to remark that Mr. H. O. Marsh has found this species very destructive to sugar beets in Hawaii, and has made a special study of it for the Bureau of Entomology.

An agromyzid fly was reared February 17, 1909, with this beet webworm from material received from Mr. H. M. Russell on beets and Amaranthus collected at Boynton, Fla.

Pegomya ruficeps Stein, an anthomyiid fly, was reared under practically the same conditions as the moth *Hymenia fascialis* Cram., above mentioned.

REMEDIES.

The remedies that have been advised for use against the garden webworm (*Loxostege similalis* Guen.) should be found about equally effective against the present species. In any case their use is advised until more is learned of the habits of the southern beet webworm. These remedies are given below.

Paris green.—Paris green is applied at the rate of 1 pound to from 75 to 100 gallons of water, or dry, distributed with a powder gun, as practiced in the South. The latter method, however, is inferior to spraying. Since the two species share common natural food plants (Amaranthus), the usual care should be exercised to avoid planting beets in fields which have grown up in this weed until after thorough fall or spring plowing.

The experience which Mr. H. O. Marsh has had with the related Hawaiian webworm conclusively shows the value of Paris green. He states, in brief, that a spray of Paris green at the rate of 2 pounds of the arsenical and whale-oil soap, 8 pounds in 100 gallons of water, proved absolutely effective and did no injury to the plants on which it was applied. The spray was applied to the underside of beet leaves.[1] More complete information in regard to this is given in Part I of the present bulletin.

It should be added that a mixture composed of nicotine sulphate, 1 fluid ounce, with whale-oil soap, 4 ounces, in 4 gallons of water, was used by Mr. Marsh against a number of noxious lepidopterous larvæ, and although this formula was not tested on the Hawaiian beet webworm, he believes that it would prove entirely effective.

Dragging the log.—In the case of a bad attack of the garden webworm in Oklahoma in 1903, a satisfactory barrier to migration was employed, consisting of a dust furrow in which a log was dragged. This might be used in case the webworm under discussion should occur in great numbers before its presence is discovered—something that is likely to happen, as in the case of species of related habits.

[1] For some reason arsenate of lead applied to both sides of Amaranthus leaves was found ineffective and no explanation could be made of this, but the chemical was probably not pure.

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PAPERS ON INSECTS AFFECTING VEGETABLES.

THE IMPORTED CABBAGE WEBWORM.

(*Hellula undalis* Fab.)

By F. H. Chittenden, Sc. D.,
In Charge of Truck Crop and Stored Product Insect Investigations,
and
H. O. Marsh, *Agent.*

INTRODUCTION, SPREAD, AND RAVAGES.

Beginning with the year 1897 the imported cabbage webworm (*Hellula undalis* Fab.) has repeatedly come under observation as a pest in new States and Territories, namely, in Florida, Mississippi, North Carolina, Texas, California, and Hawaii.

In 1907, Mr. H. M. Russell observed attack to collards at Lakeland, Fla., in June and July, to collards at Orlando, Fla., in July, and at Dade City, Fla., to cabbage in December. The species has undoubtedly been in that State for many years, since it has been known for more than a decade from South Carolina to Georgia, but this is the first record of injurious occurrence there.

In November, 1907, Prof. R. I. Smith reported injury to cabbage at West Raleigh, N. C. Whether this insect will be able to establish itself much farther north than the Carolinas is problematical. Our records show complete establishment throughout the Gulf States; in fact, the insect occupies a considerable portion of the same territory as that permanently inhabited by the harlequin cabbage bug (*Murgantia histrionica* Hahn), save that the latter, having been introduced many years earlier, is better known and occurs farther northward.

A review of the distribution of this species shows that it first came under notice as a pest in 1897, when it was destructive to crucifers about Augusta, Ga. Here it did great injury during that and the succeeding year. In after years it was observed in various other localities in Georgia, at Auburn, Ala., and at Charleston and Beech Island, S. C. Later it was noticed as a pest in Texas.

The list, which will be furnished under the heading of distribution, simply includes the localities reported to this bureau and is doubtless

far from being complete. The mere occurrence of this insect at Los Angeles, Cal., was observed as early as 1891 or 1892, but nothing further was heard of the insect in the Pacific States until 1907, when it was reported by Messrs. Ball and Titus, working on sugar beets in that same region.

In 1908 the species came under the observation of the junior author on several occasions in Orange County, Cal. In October it was found attacking horse-radish and cabbage at Santa Ana in the customary manner, namely, feeding in the heart, webbing the leaves, and eating out the tissues. At Garden Grove, Cal., it was attacking cabbage and mustard.

During June, 1908, Mr. D. K. McMillan observed this species on radish, cabbage, and kale at Brownsville, Tex., the plants being considerably damaged. The larvæ in most cases had destroyed the "buds" or had bored down into the center of the plants. They seemed to attack only the midrib of kale and most cabbage plants, feeding in a groove on the upper surface, which they cover with a web, varying this by eating a small cavity extending along the interior from one-fourth of an inch to an inch in some cases. Larvæ were observed on rape at Mission, Hidalgo County, and at Santa Maria, Cameron County, Tex. At Brownsville they were found in November on mustard cultivated for table use. At this time many were found with tachina eggs placed in the usual location near the head. Turnip tops were also affected, the work on turnip and mustard being similar to that observed on rape and radish. The larvæ concealed themselves along the midrib, boring down into it as well as along the groove, with a covering of silk under which they are fairly well protected.

From finding the insect in many localities, in several cases not in destructive numbers, Mr. McMillan expressed the opinion that the species in southern Texas is evidently largely controlled by parasites and other natural enemies, as most individuals observed, even in June, were parasitized. It is probable that the species is well distributed throughout nearly the entire State of Texas, and, although held in check during most seasons by natural enemies, there is always the likelihood that at any time it may crop out as a serious pest.

October 17, Mr. Charles M. Jones, Stallo, Miss., reported injury to turnip and collard. The larvæ were not so active when the weather was cool and appeared to work at all times of the day. An entire crop of collards was destroyed.

In Mississippi, also, Mr. M. M. High found larvæ September 9, 1909, in large numbers on cabbage and turnip near Columbia. He described them as beginning work by first spinning a web in which to retreat. They then eat out the ends of young plants and check their growth, besides causing the death of some of them. They did much damage, cutting out the "buds" of young cabbage, in addi-

tion to devouring the remaining leaflets and spinning their small but conspicuous webs over the plant. A grower here stated that the damage seemed greater that season than heretofore, and that he should have been marketing cabbage, but had none that had small heads, all having been destroyed by this larva.

He had tried to poison the larvæ with Paris green applied dry, but with little success. The webs prevent the poison in powdered form from reaching the caterpillar in its protected feeding quarters.

The insect infests the turnips to about the same extent as cabbage, while it seems to be not quite so serious with turnips.

September 16, 1909, the larvæ did considerable damage to cabbage and turnips at Kosciusko, Miss. When first hatched they are difficult to find, because of their habit of concealing themselves in the crotch of a stalk and turning the edges of the leaflet back, forming a domicile into which they retreat when not feeding.

September 24, this pest was seen in large numbers on turnips at Crystal Springs, Miss. Many had already transformed to adult, as many cocoons were found containing empty pupal cases. This pest had destroyed about 16 per cent of the turnips upon the plat and many dead leaflets were found among the remaining green ones, due to its ravages. Hundreds of moths were flying over the patch, alighting upon turnips and upon the ground. It was thought that the insect was destined to do greater damage before the season was over, as many larvæ were still spinning their webs and devouring the leaves.

The part of the plat most seriously affected by the pest was not nearly so well fertilized as the remaining portion. The portion where most damage was done was upon high dry land, while the remaining portion was upon damp rich soil. This same species was observed cutting buds from late cabbage at Columbus, Ridgeland, Starkville, and Gulfport, Miss. Mr. High wrote:

> The moth undoubtedly deposits her eggs near the "bud," where they hatch, the young larvæ devouring the bud, spinning webs, tying the larger leaves together, one to three larvæ going to each leaflet, curling the edge of the leaf and forming an individual web, and, later, spinning a cocoon to transform into the pupal stage. The larvæ come out of these webs to feed and then retreat when their hunger has been satisfied. This is one of the most serious pests of the truck grower about Crystal Springs, Miss.

It is evident that this remark may apply to practically the entire State of Mississippi, and that similar conditions obtain in Georgia and South Carolina.

February 3, 1909, Dr. W. E. Hinds, entomologist to the Alabama Experiment Station, Auburn, Ala., wrote that he had received this species from Phoenix City and Montgomery, besides Auburn.

October 2, Mr. High reported that he had again found this pest at Gulfport, Miss., both upon late cabbage and turnips. Injury was

more serious on young cabbage, because the "buds" were being devoured and small webs filled with excrement were left in their stead. There was only a small plat of cabbage where, on the other hand, there were acres of turnips. The webs were distributed also over the turnips, some of them being empty, the larva having transformed to the moth. This pest was doing great damage to the two truck crops. Some other pests were associated with it and were doing some injury, such as the flea-beetle (*Phyllotreta bipustulata* Fab.) and the cabbage looper (*Autographa brassicæ* Riley).

During the fall of 1909 the late F. C. Pratt reported this webworm as a pest to cruciferous crops at Sabinal, Tex. About the middle of January, 1910, the junior author visited Sabinal and in company with Mr. Pratt examined the gardens where injury had occurred. The characteristic work of the larva was observed on radish and cabbage, which remained as crop remnants, but none of the insects was found. Mr. Pratt said he had taken an adult, out of doors, late in November and expressed the opinion that the insect might winter in the adult condition in that locality.

October 22 the larva was observed in large numbers at Columbus, Miss., upon cabbage, turnips, and collards grown by Mr. J. E. Slaughter. The larvæ bore into the stems of the cabbage and turnips for some little distance or eat out small crevices in the edges of the stems, enough to bury their bodies, and then, spinning a cocoon, they transform into pupæ.

November 2, 1909, the larva was found by Mr. M. M. High in large numbers at Starkville, Miss., upon turnips. The larva was observed in the crotch of every other plant, boring and hiding from the light. From one to three were found in the "buds." Fully 50 per cent of the turnip crop under consideration had the buds destroyed by this imported webworm. The plants attacked had small roots and looked stunted or checked in their growth.

This insect seems to do the greater damage to cabbage and turnips, although injury to collards is by no means slight, especially while the latter are young. The larva seems to prefer turnips in the row to those sown broadcast. There was not a plant, either cabbage or turnip, but that contained from two to many of these larvæ.

December 3, 1909, Mr. High found webworms of this species in large numbers in the crotch and stems of turnips at Hattiesburg, Miss., where they concealed themselves beneath their webs, destroying the most vital portion of the plant. One grower stated that this insect was a perfect nuisance to older plants and a menace to young ones. He said:

> The little striped worm enters the bud of both cabbage and turnip when the plants are quite young and devours them, thus forcing the plant to grow a new bud and start or begin new growth—my first crop of cabbage in the spring being almost totally destroyed from the work of this striped worm.

The cabbage plat now appears to be unmolested by this larva, while nearly every turnip in the plat adjoining cabbage has one or more of the larvæ somewhere near the base of the stems or leaves.

A few mature larvæ were found at Brownsville, Tex., November 5, 1910, boring in stems of mustard and crowns of young cabbage plants. Evidence of past injury was common and indicated that the larvæ were more numerous in early October. Several cabbage growers stated that worms, which from their description were evidently this species, caused considerable damage in seed beds. One grower lost fully 50 per cent of his plants, which had the bud destroyed and were worthless for planting.

Turnip, radish, and mustard plants in the earlier stages were generally attacked and stunted or caused to grow misshapen, and in some cases were entirely destroyed, the larvæ boring down into the base of the crown and upward into the leaf stems after eating out the crown. Several larvæ attacked a plant simultaneously.

At a meeting of the truck growers on the Indiana Canal, 5 miles east of Brownsville, Tex., held November 28, 1910, nearly everyone reported more or less damage to seed beds of cabbage in October. Several had tried dusting with Paris green and lime, but evidently after the injury began to be noticed the larvæ could not be reached in their burrows under the protection of the web. Very few sprayers were in use among the farmers, who were mostly newcomers in this section. At Henry Keller's at least 25 per cent of his seed beds were ruined, and in small areas about 75 per cent had the bud eaten while the plants were small. More than 25 per cent of his young cauliflowers set in the field were injured, and in many cases would not make perfect heads. There were a few small larvæ found at this place and several adults were observed.

Particulars in regard to earlier occurrences are given by the senior writer in the following bulletins of the Bureau of Entomology: No. 19 (pp. 51–57), No. 23 (pp. 53–61), and No. 33 (pp. 48, 49).

DESCRIPTION AND LIFE-HISTORY NOTES.

THE MOTH.

The moth is illustrated at *a* of figure 4. It is gray in color, with the forewings marked and mottled, as shown. The wing expanse is about five-eighths of an inch (18 to 21 mm.). The following technical description is copied from Dr. Hulst's paper (4):

Palpi, head, thorax, and abdomen fuscous; forewings broken fuscous and fuscous cinereous; the basal space with a black spot medially, two white lines across the wings, the first extra basal edged with dark fuscous, the outer after the typical *Botis* pattern; a dark-brown spot annulate with white at reniform; a dark-brown subtriangular apical patch, and a subterminal white line; marginal line black, broken; hind wings, even fuscous; beneath, lighter, lines obsolete, reniform indistinct.

The following synonymy is recognized:

Hellula undalis Fab., Ent. Syst., vol. 3, 2, p. 226; Herrich-Schäffer, Eur. Schmett., vol. 4, pl. 8, f. 54.
Scoparia alconalis Walker, Catalogue, vol. 19, p. 827.
Leucinodes exemptalis Walker, Catalogue, vol. 34, p. 1313.
Botys rogatalis Hulst, Trans. Amer. Ent. Soc., vol. 13, p. 149.

The wing venation, head, and antenna are shown in figure 5.

THE EGG AND OVIPOSITION.

A pair of moths newly reared was placed in a vial July 24, and next morning the female was found to have deposited singly, doubly, and in masses of from 3 or 4 to 20, a total of 235 eggs. The following day 24 were laid; on the 27th, 37 were found, or 296 in all. Afterwards the moth died, having laid no more. A few eggs were found upon dissection, making the probable number usually deposited between 300 and 350.

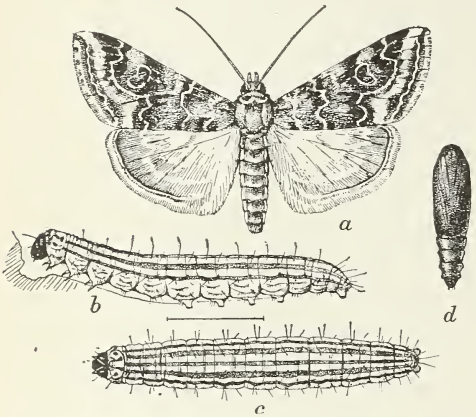

FIG. 4.—The imported cabbage webworm (*Hellula undalis*): *a*, Moth; *b*, larva, lateral view; *c*, larva, dorsal view; *d*, pupa. All three times natural size. (From Chittenden.)

Most of the moths die in confinement within a week.

The egg.—The egg is of sufficiently large size, about four one-hundredths of an inch in length, as to be readily discernible to the naked eye. It is of oval form and rather variable in contour, being usually more or less flattened upon the surface of deposit, and there is often a distinct nipple at one extremity. Its greatest width is about three-fifths its length. The color when first laid is light gray, and under a strong hand lens the surface appears to be rugose and strongly iridescent. Under a higher power the surface is found to be made up of depressed irregular areas, mostly hexagonal and pentagonal in outline.

Length, about 0.5 mm.; greatest width, 0.3 to 0.35 mm.

FIG. 5.—The imported cabbage webworm: Wing venation, head, and antenna. All enlarged. (After Hampson.)

A day after deposition the eggs begin to take on a pinkish hue, due to light reddish spots below the surface. On the second day the embryo can be detected, the head showing as a blackish dot near one end and on the lower surface of the egg or the side of attachment.

Experiments conducted in the latter days of July, in a temperature officially rated by the Weather Bureau of this department as mod-

erate (indoor 80° to 84° F.), showed that the eggs hatched three days after deposition, a rather remarkably short period for the eggs of a moth with a wing expanse of nearly three-fourths of an inch.

THE NEWLY HATCHED LARVA.

The larva when just hatched measures about a millimeter in length and about a twelfth that in diameter across the abdomen. The head, as is usual with young larvæ, is prominent, wider than the body, and dusky in color. The thoracic plate is also dusky and of somewhat similar subcrescentic form to the more mature stage. The body is very pale yellowish gray, nearly white, and the surface is moderately clothed with long, fine hairs.

Very soon after hatching the larva shows the characteristic striæ of the more mature form. Thus larvæ 2 mm. in length are so little different in general appearance from the full-grown ones as to be readily recognized as of the same species.

THE FULL-GROWN LARVA.

The full-grown larva, shown at *b* and *c* of figure 4, measures a little upward of half an inch in length, being about six times as long as wide.

The form is subcylindrical, tapering toward each extremity, widest near the middle—the third, fourth, and fifth abdominal segments being nearly equal. The general color is dull opaque grayish-yellow or yellowish-gray, striped with broad, somewhat irregular, brownish-purple, longitudinal bands, which extend from the second thoracic to the terminal or anal segment. These are bright and conspicuous on the dorsal and more feebly indicated on the ventral surface. The dorsal stripes are five—a moderately wide medial one, a broader mediolateral on each side, and a dorso-lateral one, of about equal width with the median one, also on each side. On each side below are two lateral lines, faint, and interrupted toward the ends of each segment; a similar ventro-lateral line; and a much fainter interrupted median line.

The head is black and shining, the V-mark well indicated, the cervical or thoracic shield is shining, light, somewhat purplish-gray, and is rather variably marked with brown, which forms, each side of the median stripe of the second thoracic segment, two irregular longitudinal dark brown patches, darkest and widest toward the posterior margin. On each side above the spiracle of that joint is a shorter dark patch. Near this there are sometimes two or three small dark rounded spots. The spiracle of this segment is dark brown, the remainder being concolorous with the body. The thoracic legs are more or less infuscated, and the prolegs are nearly concolorous with the venter. The entire surface of the body is sparsely covered with moderately long yellow and light brown hairs, proceeding from small and shining piliferous tubercles.

The anal shield bears from 10 to 12 round purplish spots, the most posterior one the largest and standing alone, the remainder forming a subcrescentic pattern.

The length when in natural position at rest is about 13 mm. and when extended 15 mm., the width being a trifle more than 2 mm. at the widest part.

THE PUPA.

The pupa is moderately shining, light yellowish brown in color and the surface is covered with a light pruinose bloom. The eyes are dark brown, varying

to black, and the dorsum is marked by a median stripe. The contracted antepenultimate segment is noticeable. The anal segment terminates in two pairs of straight brown hairs. It is of rather robust cylindrical form, measuring about three-tenths of an inch (7.5 mm.) in length and one-twelfth (2 mm.) in width.

The somewhat peculiar outline of the abdominal segments is shown at *d* of figure 4.

Transformation to pupa and thence to imago takes place in a rather compact cocoon composed of webbed-up grains of earth, which the larvæ form after burrowing into the soil. Those before the writer measure about three-eighths of an inch (9 mm.) long and a little less than half that in width.

The notes which appear above, on the life history of the species, were made by the senior writer at Washington, D. C., where the temperature and other conditions are not materially different from those of the Eastern Gulf States.

DISTRIBUTION.

In previous articles it was stated that this species would probably not spread beyond certain natural boundaries, i. e., not much above the Lower Austral life zone. Thus far this prediction has been verified.

The following is the known distribution as recorded in this branch of the bureau: West Raleigh, N. C.; Charleston and Beech Island, S. C.; Auburn, Phoenix City, and Montgomery, Ala.; Augusta, Waycross, Tifton, Athens, Griffin, Montreal, Albany, Marshallville, Macon, Fort Valley, Meansville, and Leesburg, Ga.; Lakeland, Dade City, and Orlando, Fla.; Stallo, Columbia, Kosciusko, Crystal Springs, Columbus, Ridgeland, Starkville, Gulfport, and Hattiesburg, Miss.; Corpus Christi, Brownsville, Beeville, Mission, Santa Maria, and Sabinal, Tex.; Los Angeles, Orange County, Santa Ana, and Garden Grove, Cal.; and Honolulu and Wahiawa, Hawaiian Islands.

The foreign localities need not be repeated.

FOOD PLANTS.

The first record of injury by this species was to cabbage, turnips, and beets. October 14, 1897, Mr. N. L. Willett, a reliable correspondent of this department, estimated that the cost to the grower of these plants and collards in the county of Richmond, Ga., alone would amount to $15,000 to $20,000 during that year, while Mr. W. M. Scott, at that time State entomologist of Georgia, estimated, November 26, 1897, a loss to that county of $50,000.

Besides cabbage, turnips and beets, collards, cauliflower, kale, rutabaga, radish, kohl-rabi, mustard, rape, horse-radish, and some other

cultivated plants, such as "Japanese radish," are subject to attack and injury. Among weeds and wild food plants are the common shepherd's purse (*Bursa* [*Capsella*] *bursa-pastoris*) and "pussley" or "cutter's grass," otherwise purslane (*Portulaca oleracea*).

NATURAL ENEMIES.

Natural enemies of cruciferous insect pests are of great value in keeping their hosts in check, and some dependence must be placed upon these agencies in restraining the undue multiplication of this webworm. Indeed, there is evidence that they do hold it in check in many regions, although they have not prevented its natural spread.

In spite of the short time that we have known of its occurrence in this country as a pest—since about 1899—we are already certain that at least five natural enemies, and probably more, are at work in decimating its numbers.

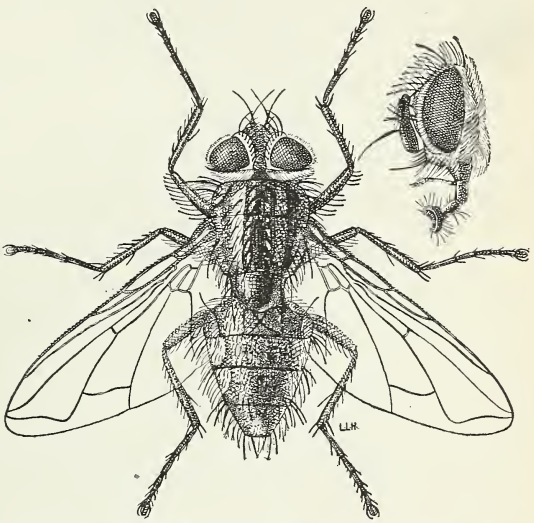

FIG. 6.—*Exorista pyste*, a parasite of the imported cabbage webworm (after Titus).

Exorista pyste Walk. (fig. 6), a tachina fly, has been repeatedly reared from the caterpillar of *Hellula undalis* from July 27 to as late as October 27.

Limnerium tibiator Cress., a very abundant parasite reared with this species, is an ichneumonid. It was reared from the latter part of October until the last week of December. It has not been positively ascertained to prey upon this larva, as it is a well-known enemy of the diamond-backed moth (*Plutella cruciferarum* Curt.), which was also present in smaller numbers, but as it is also known to attack the cabbage looper (*Autographa brassicæ* Riley) and *Mineola indiginella*, it seems probable that it is in reality an enemy of this webworm.

Plagiprospherysa sp., a tachinid fly parasite, was reared June 12 and 17, 1908, from its host from Brownsville, Tex. The identification was made by Mr. C. H. T. Townsend.

Two other hymenopterous parasites of this webworm, reared in 1899, were identified by the late Dr. William H. Ashmead as *Meteorus vulgaris* Cress. and *Temelucha* (*Porizon*) *macer* Cress., female. The

former, an ichneumonid, was reared in September from material received from Auburn, Ala.; the latter, a braconid, issued during the latter days of July from larvæ received from Charleston, S. C.

November 12, 1908, Prof. R. I. Smith, West Raleigh, N. C., stated that in attempting to rear larvæ of this species several were killed by mites, which bred in great numbers in a single night. Samples of the mites were forwarded to this office, for identification by Mr. Nathan Banks, who reported as follows:

> The mite is *Tyroglyphus americanus* Bks., a species common in the Eastern States and feeding on a great variety of substances. These mites have a migratory stage which is attached to many insects, and so they gain access to places where one would not suspect them.

THE IMPORTED CABBAGE WEBWORM IN HAWAII.

In Hawaii the larvæ of the imported cabbage webworm (*Hellula undalis* Fab.) were observed by the junior author[1] attacking cabbage, radish, kohl-rabi, and "Japanese turnips," at Honolulu and Wahiawa, on the island of Oahu. The investigation was confined to this island, and it was not determined if the species occurs as a pest on the other islands of the Hawaiian group.

On Oahu cabbage and a few other cruciferous crops are produced to a limited extent throughout the year, for consumption in the local market. Of these crops cabbage is probably the most valuable, although "Japanese turnips" are grown and used quite extensively by the Orientals. These turnips resemble what we in the States call "winter radish," but, unlike radishes, they are cooked before being eaten.

Most of the cabbage is grown during the cooler months, from November until April. According to the oriental gardeners, the other months of the year are "too hot," and the plants seemingly do not thrive. Ordinarily only a few acres are grown annually, and the production is so limited that it becomes necessary to import considerable quantities of this vegetable from the mainland to supply the demand at Honolulu and other towns. Cabbage grown during the cooler months is usually of good quality and is said to be a profitable crop. Under the circumstances it doubtless seems odd to one unacquainted with the conditions that this crop is not produced in sufficient quantities to supply the local demand. The failure to grow cabbage more extensively is due in part to the fact that this crop is preyed upon by a horde of insects. Although most of these pests can be easily controlled, the Chinese and Japanese gardeners are,

[1] The notes on the occurrence of the imported cabbage webworm in Hawaii were made by the junior author while engaged as assistant Territorial entomologist and as a collaborator of the Bureau of Entomology. Thanks are due Mr. E. M. Ehrhorn for the courtesy of allowing Mr. Marsh to retain these notes. The junior author is not responsible for any statements made in other portions of this paper.—F. H. C.

almost without exception, ignorant of methods of control, and as a result much of the crop is injured and the growers become discouraged and plant other crops which are less damaged by insects.

Among these insects are the common cabbage worm (*Pontia rapæ* L.), the imported cabbage webworm (*Hellula undalis* Fab.), cutworms (*Agrostis crinigera* Butl.), a looper (*Autographa precationis* Guen.), the diamond-back moth (*Plutella maculipennis* Curtis), the beet army worm (*Caradrina exigua* Hübn.), the cabbage aphis (*Aphis brassicæ* L.), the spinach aphis (*Rhopalosiphum dianthi* Schrank), and a number of minor pests. Among the latter is a leaf-miner (*Agromyza diminuta* Walk.), an unidentified species of thrips, and the melon fly (*Dacus cucurbitæ* Coq.). The larvæ of the melon fly work in cabbage which has previously been injured by the larvæ of *Hellula undalis*. This fruit fly is an exceedingly destructive enemy of cucurbits, and its occurrence in cabbage is rather uncommon.

The operations in Hawaii occupied a period of about seven months (July, 1910, until February, 1911), and during this time the insects affecting cabbage were kept under fairly constant observation. During this period the imported cabbage webworm apparently caused more damage to cabbage than any other insect. The growers claim, however, that from January to April the common cabbage worm (*Pontia rapæ* L.) is the most troublesome pest. During the period of actual observation, however, the webworm appeared to outrank the other species in destructiveness; in fact, at least a few of the webworms could be found whenever a search was made for them, although cabbage and turnips were the only crops which were noticeably damaged. The most serious infestation observed in 1910 occurred at Wahiawa, Oahu. On October 10, in company with Mr. E. M. Ehrhorn, a visit was made to a grower at Wahiawa, who planned to grow about 7 acres of cabbage that season. At this time he had three seed beds containing thousands of small cabbage plants. In one bed many plants had been killed, and of those which remained fully 75 per cent were infested by webworms and were worthless. In the other two beds in another field, at a distance of about 200 yards from the first, about 10 per cent of the plants were infested. The larvæ in the seed beds were all small. On large cabbage plants in a garden, a mile or more from the seed beds, full-grown larvæ were found in moderate numbers. One moth was observed, but no eggs were seen. In small garden patches at this place the Japanese killed occasional larvæ which lived in folded leaves or between two leaves, by crushing them with the fingers. Apparently only larvæ of conspicuous size were found, and as the majority of the webworms mined into the plants, beyond the reach of hand-picking, this method of control seemed of doubtful value.

The seed beds were again visited October 17. The conditions had not materially changed, except that some larvæ had reached maturity and left the plants. On November 2, 3,000 plants were taken from the three beds and transplanted to a field fully 2½ miles from the seed beds. The plants were carefully examined and only those free from larvæ were transplanted. Unfortunately, small patches of old cabbage and Japanese turnips occurred but a short distance from the transplanted plants. The old cabbage was not badly infested, but the webworms were abundant in the turnips, and a portion, about one-fifth of an acre, of one patch was nearly destroyed. It will thus be seen that, although the young plants were free from larvæ when transplanted, they were placed in a badly infested and dangerous neighborhood. When these plants were examined November 18 nearly every one in the entire patch was found infested with from 1 to 10 webworms. These were mostly small—very few more than a week old—and many were not more than 4 days old. They had burrowed into or between the tender, curled leaves at the "bud" and were so well protected that they were apparently beyond the reach of a spray. Even at this early stage the plants showed plainly the results of infestation. It was obviously a hopeless case, and the man in charge, a Japanese, was advised to pull up the plants and burn them, but this he refused to do. At the next visit, December 8, little remained of these plants but stunted, worthless stumps. Larvæ were still abundant in them, although many had reached maturity and burrowed into the soil. About 700 plants which had been set out shortly after the middle of November in an adjoining patch were also generally infested and were rapidly becoming worthless.

In summing up these observations it will be seen that nearly 4,000 transplanted plants were destroyed by webworms, while at the same time the plants in seed beds were so generally infested that it was almost impossible to procure stock for replanting.

One of the most obvious factors making possible this loss was the almost utter indifference with which the necessity of clean culture was regarded. Old cabbage stumps and abandoned seed beds were not promptly destroyed, but were allowed to serve for months as breeding centers. An essential lesson that these growers have to learn is the absolute necessity of promptly destroying remnants of the crop by burning or some other equally effective method.

LIFE HISTORY AND HABITS.

Under normal conditions the eggs, when deposited on cabbage, are placed about the "bud" at the axils of the terminal leaves or on the leaves. From 1 to 12 eggs may be deposited on a single small plant.

At Honolulu eggs have been observed to hatch in from two to three days. Within a very short time after hatching the larvæ endeavor to conceal themselves. When very small cabbage plants in seed beds are infested the larvæ conceal themselves by folding a tender leaf and fastening the edges together with a web. Rarely is more than one larva found on a single leaf. With somewhat larger plants the larvæ mine into or crawl between the curled, terminal leaves at the "bud," and, as they increase in size, burrow deeper into the main stalk. When a plant is thus infested it is rendered worthless. With large plants which are beginning to head the larvæ mine into the midribs or live in burrows between two leaves. The chief damage is caused by the larvæ destroying the "buds" of the small to medium-sized plants. When the "buds" of small plants in the seed bed are attacked the plants may be killed outright. With larger plants the destruction of the "bud" effectually prevents further normal development. Rain falling into the burrows hastens decay, thus completing the injury begun by the larvæ. On Oahu the larvæ are called "center worms," from their habit of mining into the center or "bud" of cabbage plants.

The larvæ usually reach maturity in from 13 to 15 days. They then leave the plants, burrow slightly beneath the surface of the soil, and form rather frail cocoons of webbed-together grains of earth, within which they pupate within 2 days. During the progress of these studies thousands of larvæ were under close observation, and they invariably burrowed into the soil and made cocoons of webbed-together grains of earth. The adults usually issue in from 6 to 12 days after pupation. They fly easily, but are shy and are rarely noticed by the casual observer.

It is probable that this species breeds throughout the year in Hawaii. Judging, however, from the reports of gardeners, it is evident that reproduction is at a low ebb during the cooler months. This idea is borne out by the fact that the larvæ were noticeably less abundant at Wahiawa in late December and at Honolulu in January than earlier in the season.

Four generations of this webworm were reared in an insectary at Honolulu. The record for the first generation is incomplete.

FIRST GENERATION.

September 2, 1910, several mature larvæ were collected from cabbage in a garden at Honolulu and confined in a cage. They burrowed into the soil September 3 and pupated September 5. The first moths, 4 in number, issued September 12, and the following day 8 more issued. The 12 moths were then put in another cage, containing a

living cabbage plant, and were supplied with diluted molasses as food. The following is a summary of the three succeeding generations:

SECOND GENERATION.

September 12–13	Twelve adults issued.
September 14	First eggs deposited.
September 16	The eggs hatched.
September 29	First larvæ reached maturity.
October 1	First larvæ pupated.
October 7	First adults issued.
October 8	More adults issued.

From the above record the stages are as follows:

	Days.
Egg stage	2
Larva stage	15
Pupa stage	6
Total	23

THIRD GENERATION.

October 7–8	Adults issued.
October 9	First eggs deposited.
October 12	The eggs hatched.
October 26	First larvæ reached maturity.
October 28	First larvæ pupated.
November 6	First adults issued.
November 7	More adults issued.

From the above record the stages are as follows:

	Days.
Egg stage	3
Larva stage	16
Pupa stage	9
Total	28

FOURTH GENERATION.

November 6–7	Adults issued.
November 9	First eggs deposited.
November 12	The eggs hatched.
November 27	First larvæ reached maturity.
November 29	First larvæ pupated.
December 11	First adults issued.

From the above record the stages are as follows:

	Days.
Egg stage	3
Larva stage	17
Pupa stage	12
Total	32

The moths which issued December 11 deposited eggs for a succeeding generation. Unfortunately, it was necessary to abandon the work at this point and records of further development were not obtained.

EGG-LAYING RECORDS.

On October 11 a pair of moths, which had issued that day, were observed mating. These moths, while still together, were put into a separate cage and the following record obtained:

	Eggs deposited.
October 13	79
October 14	49
October 15	31
October 16	32
October 17	13
October 18	15
October 19	5
October 20	11
Total	235

The female died October 21 and the male died the following day. The female lived 10 days and deposited 235 eggs. The male lived 11 days.

With another mating pair, which were likewise confined during October, the female lived 14 days and deposited 237 eggs. The male lived 17 days.

The life-history records were obtained in an open-air insectary in which open wire cages were used. Food was supplied the moths by putting in wads of absorbent cotton which had been saturated with molasses and water. They fed on the diluted molasses eagerly. The moths were docile and easily handled, and mating pairs were readily obtained during the daytime. In all cases, cabbage was used as food for the larvæ. Usually young, tender plants from seed beds were supplied.

Following is the temperature record at Honolulu during the time the species was reared:

Month.	Minimum temperature.	Maximum temperature.	Average mean temperature for entire month.
1910.	°F.	°F.	°F.
September	69	85	77.0
October	65	84	75.3
November	66	84	74.6
December	62	80	71.2

NATURAL ENEMIES IN HAWAII.

Many larvæ were collected at various dates from cabbage and other cruciferous plants in the gardens in Honolulu and Wahiawa

and confined in cages. No parasites were obtained, nor were predaceous enemies observed in the field. In one or two so-called stock cages in the insectary, which were crowded with surplus webworms and neglected, a disease or "wilt" developed which killed many larvæ. This "wilt" did not occur in the regular cages and was not observed in the field. Apparently, as far as Hawaii is concerned, this webworm seems to be remarkably free from natural enemies.

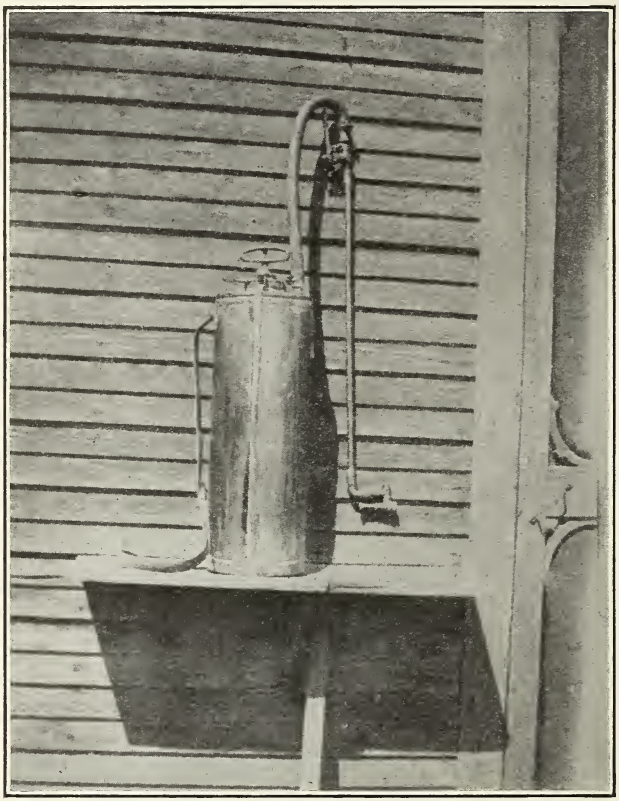

FIG. 7.—Small compressed-air sprayer, fitted with extension rod, elbow, and Vermorel type nozzle. (Original.)

EXPERIMENTS WITH INSECTICIDES.

During the fall of 1910 some experiments were made against this webworm. All experiments with insecticides were conducted on infested cabbage in a garden at Honolulu. In all cases the insecticides were applied with a small compressed-air sprayer (fig. 7), which was fitted with a short extension rod, elbow, and a small nozzle of the Vermorel type. The experiments were as follows:

Experiment No. 1.—Paris green, 2 pounds, and whale-oil soap, 8 pounds, in 100 gallons of water.

September 7 the plants in two seed beds and 495 older plants were sprayed. One seed bed contained plants from 1 to 3 inches in height, many of which were infested by small webworms. They had not entered the bud, but were working in folded leaves.

The second bed contained larger plants ready to transplant and only slightly infested. The few larvæ present were mostly in small folded leaves or occasionally in a bud. The 495 plants had been transplanted for some time and varied from small plants, which had made little growth, to a few which had just begun to head. In fully one-fifth of these plants the bud had been destroyed by webworms, making the plants worthless.

In this experiment the plants were simply wet from above. In the seed beds the entire upper surface of the plants was wet, but with the larger plants only the leaves at the center were reached. The mixture adhered very well. At the time of the application all the larvæ were concealed in the folded leaves or buds. The weather was hot and clear.

In the seed bed containing the small plants a few larvæ were dead the following day (September 8). They were found clinging and exposed on the surface of the leaves.

The plants sprayed in the second seed bed had been removed and transplanted. The infested ones were discarded, and as a result the effects of the treatment could not be determined.

In the large plants the larvæ were buried beyond the reach of the poison and none were killed.

September 9 it was noted that a few additional larvæ had died in the first seed bed. Some of the leaves were slightly burned by the arsenical. On the old plants no effect was apparent, either upon the larvæ or upon the foliage.

A heavy rain occurred September 10 which washed the poison from the plants, and the experiment was closed on that date.

As a result of this treatment only a moderate number of larvæ, in the folded leaves on the young plants, were killed. With the large plants no larvæ were killed. All things considered this experiment must be rated as a failure.

Experiment No. 2.—Paris green, 5 pounds; lime, 5 pounds; and whale-oil soap, 10 pounds, in 100 gallons of water.

September 12 a seed bed of small, well-infested plants was sprayed. The larvæ were practically all in folded leaves and only one was found entering the bud. The spray mixture adhered perfectly and the surface of the leaves was thoroughly coated with the poison. The weather was cloudy and sultry.

A shower occurred the following day, but the poison was not washed from the leaves. No dead larvæ could be found at this time. Some of the leaves were slightly burned.

September 15 the application was repeated. The older leaves were still well coated with the poison from the first dose, but many new leaves had been put out and these were unprotected. All were completely coated by the second spraying. At this date there were occasional dead larvæ, but they were not common.

September 16 it was noted that some of the larvæ were actually entering the bud and that very few of them had been killed.

Heavy showers occurred September 18, 19, and 20, but the coat of poison remained fairly good. At this latter date, most of the larvæ were in flourishing condition, and the experiment was considered a failure. The plants were slightly burned, but no serious damage resulted. One interesting point brought out by this experiment is that the mixture was remarkably adhesive and not readily washed from the foliage by rains.

Experiment No. 3.—Arsenate of lead, 5 pounds, and whale-oil soap, 10 pounds, in 100 gallons of water.

October 12, 418 good-sized cabbage plants were sprayed. The larvæ were moderately common. All were deeply buried and obviously beyond the reach of the poison. The mixture adhered well and the plants were completely coated. These plants were examined daily until October 19, but not a dead larva was found, and at that date the experiment was abandoned as a complete failure. The mixture did not burn the foliage.

Experiment No. 4.—Paris green, 2 pounds, whale-oil soap, 8 pounds, and nicotine sulphate, 25 ounces, in 100 gallons of water.

November 10, 410 good-sized moderately infested plants were sprayed. These plants were kept under almost daily observation until November 23, but not a dead larva was found. This mixture did not burn the plants, and it completely wiped out plant-lice (aphides) and several species of lepidopterous larvæ which were exposed on the leaves. It was, however, ineffective against the well-protected Hellula larvæ.

The experiments with insecticides may be summarized as follows:

Experiment No.	Date.	Insecticide used.	Effect on larvæ.	Injury to foliage.	Remarks.
	1910.				
1.....	Sept. 7	Paris green, 2 pounds, and whale-oil soap, 8 pounds, in 100 gallons of water.	Ineffective..	Not worth mentioning.	A few larvæ, in folded leaves, on small cabbage plants were killed. None were killed on large plants.
2.....	Sept. 12	Paris green, 5 pounds, lime, 5 pounds, and whale-oil soap, 10 pounds, in 100 gallons of water.	.....do.....	.....do.....	A few larvæ, in folded leaves, on small cabbage plants were killed.
3.....	Oct. 12	Arsenate of lead, 5 pounds, and whale-oil soap, 10 pounds, in 100 gallons of water.	.....do.....	None.....	Applied to large cabbage plants. No larvæ were killed.
4.....	Nov. 10	Paris green, 2 pounds, whale-oil soap, 8 pounds, and nicotine sulphate, 25 ounces, in 100 gallons of water.	.....do.....	.....do.....	Do.

EXPERIMENT IN SCREENING A SEED BED.

On October 18 two cabbage seed beds were planted at Wahiawa. The beds were about 11 yards in length and nearly 1 yard wide. They were separated by a path about 12 inches in width. One bed was screened and the other was left uncovered in the usual manner.

The screen was made by placing 12-inch boards on edge around the sides and ends of the bed, and over this a strip of cotton cheesecloth was tacked. This strip of cloth was a yard wide and a little more than 11 yards in length. It cost 5 cents per yard. It was originally intended to make the cover of the fine-meshed, cotton mosquito netting, but as this netting was not obtainable at the time cheesecloth was used instead.

These beds were examined November 8. At that date the plants in the exposed bed were well infested by Hellula larvæ. The plants in the screened bed were free from insect pests and were larger and in better condition than those in the exposed bed. Their condition was accounted for by the fact that the screen prevented rapid evaporation, as well as insect attack, and the abundant moisture and freedom from insects favored a thrifty growth.

November 18 fully 75 per cent of the plants in the exposed bed were ruined or injured by webworms. The plants in the screened bed were free from webworms and other insect pests and were of sufficient size to transplant. Owing to the protection they had received and their rapid growth, these plants were quite tender, and it was necessary to remove the cover and expose them to the sun to harden them. After being exposed a little more than a week the plants were well hardened, and several thousand were successfully transplanted.

A final examination of the transplanted cabbages was made December 23. At that date most of them were growing vigorously and only a few were infested by webworms.

On the whole this experiment was a success, although it is very evident that a mistake was made in using cheesecloth for the cover. This material shaded the plants from the sun and their growth was too rapid. Undoubtedly mosquito netting would have been an ideal cover.

CONCLUSION.

The observations on this webworm have been made under normal field conditions in several localities in Texas, California, and the Hawaiian Islands. Basing an opinion on the studies and experiments made in these places, arsenicals can not be depended on to control this species on cabbage. This belief is strengthened by the experience of Mr. M. M. High, who reports, as mentioned on another page of this article, that dry Paris green was unsuccessfully used against this pest on cabbage in Mississippi during 1909.

After the larvæ have crawled between the terminal leaves or mined into any portion of the plant they are beyond the reach of a stomach poison. The period between the hatching of the eggs and the concealment of the larvæ is so brief that it appears to be a practical impossibility to reach them under field conditions.

In the light of our present knowledge, the best methods of controlling this webworm consist of clean culture, the screening of seed beds, and thorough cultivation.

The necessity of prompt destruction of crop remnants and the employment of other clean cultural methods can not be too strongly emphasized. It is a disgraceful condition to allow worthless plants to serve as breeding centers for pests which will infest later planting.

By screening the seed beds it is possible to prevent infestation until the time of transplanting. When this method is followed it is advisable to leave a few plants exposed near the screened beds. These exposed plants will attract the moths, and eggs will be deposited on them. As soon as the eggs have hatched and the work of the larvæ becomes apparent these plants should be promptly burned.

Inasmuch as the larvæ of this species pupate in frail cocoons near the surface of the soil, it is possible that thorough cultivation would crush some of the pupæ and at the same time induce a more vigorous growth of the plants.

RECOMMENDATIONS FOR CONTROL.

While the limited stay on the part of the junior writer in Hawaii did not permit of experiments with other remedies than those which have been considered on previous pages, nevertheless it is believed by the senior writer that in the occurrence of this insect in the southern United States and in California it may be possible to successfully treat it on cabbage and other cruciferous plants by means of some form of spray, particularly if applied at the outset of attack. This point can never be too strongly emphasized, that if we expect to meet with success in combating this as well as so many other insects, work must be begun upon the first appearance of the insects each season, since if the pests can be destroyed then, it should materially decrease the injury for the entire year. If the first generation is missed, the second and third should be treated.

It should be stated that Mr. H. M. Simons, Charleston, S. C., one of the first to report this species as a pest in America, found that a mixture of kerosene oil and soap sprayed upon infested plants served as a deterrent against the larvæ of this moth, but that the larvæ returned as soon as the odor of the kerosene had become exhausted. Kerosene-soap emulsion and nicotine solutions and whale-oil soap should be given thorough tests as deterrents and insectides, both alone and mixed with arsenicals.

Another method was tested by Mr. Simons. He captured many of the moths with the aid of a barrel having all but four of the staves sawed out, leaving 4 inches from the bottom to form a tub in which to hold water. From the top of this a light was suspended which attracted the moths. In this way he caught a great many insects in two seasons. The light barrels, as he terms them, were placed on seed beds of cabbage.

A thin scum of kerosene was used in this experiment, but it is suggested that this be eliminated in order not to destroy the predaceous insects, such as ground beetles and parasites, which are practically certain to be attracted. This suggestion is made in view of the fact that the destruction of one beneficial ground beetle or parasite is equivalent to the destruction of, perhaps, from 20 to 100 injurious insects. The predaceous and larger parasitic insects can be easily picked from the water, and though they may be apparently dead, it will soon be seen that they recover and crawl away. The moths are not apt to recover.

There can be little doubt that Bordeaux mixture sprayed on the plants when they are first set out, or when they first appear above ground, and continued at intervals of a week or two, should act as a deterrent of attack. It is advisable, therefore, in using an arsenical, to employ Bordeaux mixture as a deterrent. Where cabbage and similar plants, liable to infestation by this insect, are set out from sash or cold frames, dipping the plants in a solution of arsenate of lead, prepared at the rate of about 4 pounds of the arsenical to 50 gallons of water, should be useful.

Among other remedies which may be suggested for employment, at least on a small scale, are the following:

Planting an excess of seed with the aim of afterwards destroying the plants which are injured by the webworm beyond redemption.

Fall plowing, a standard remedy for many insects.

Clean culture, or the maintenance of the cabbage or other fields throughout the season free from weeds, especially cruciferous weeds, and prompt destruction of dead or dying plants during the season and the removal of all cabbage heads, stalks, and other refuse. All cruciferous crops should be treated in a similar manner.

The refuse material, including hopelessly injured cabbage heads and other crucifers, should be gathered in piles and promptly burned. The addition of straw or similar dry material will aid in ignition.

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[1] Since the economic bibliography of this species has never been fully written out, to the writer's knowledge, the above list, which is somewhat complete, has been compiled with the assistance of Mr. Thomas H. Jones, of the Bureau of Entomology.

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PAPERS ON INSECTS AFFECTING VEGETABLES.

A LITTLE-KNOWN CUTWORM.

(*Porosagrotis vetusta* Walk.)

By F. H. Chittenden, Sc. D.,
In Charge of Truck Crop and Stored Product Insect Investigations.

INJURIOUS OCCURRENCE.

During the past decade authentic evidence, based on specimens which have been reared to the adult, has been received of the injuriousness of the cutworm *Porosagrotis vetusta* Walk., and complaints have reached the bureau of other cases of injury doubtless wrought by the same insect.

April 22, 1901, Mr. R. W. Caviness wrote from Southern Pines. N. C., sending numerous specimens of this cutworm, many nearly mature, with information concerning its ravages. His place at that time was described as literally alive with them, and there was an outbreak of the same species the previous year (1900), when it was impossible to get a stand of watermelons until the cutworms had matured. They seemed to eat "every green thing." Many cutworms were found on and about dewberry, sometimes a dozen or more to a vine. They crawled up the vines and ate the buds and leaves, and treated young peach and other trees in the same manner. It was impossible to get a stand of beans, cabbage, or any other garden "stuff." They were described as most abundant and doing their worst damage on cowpeas. In 1900 they cut fall-sown turnips until the weather became too cold for the larvæ to work.

May 18 Mr. Caviness made another sending of this cutworm taken from melon vines, 100 having been caught in an hour's time. They infested small vines that were just coming up, entirely destroyed one field of corn, and it was found necessary to replant both melons and corn. The land had previously been planted to cowpeas, but there was no apparent reason why this crop had any influence on the

development of the cutworm except for some evidence that it might be a preferred food plant.

The moths issued in our rearing jars during the first and second weeks of September, and conditions were such at that time that this is probably about the same period of issuance as that under natural conditions.

In May, 1902, this cutworm was again very abundant in the same locality, particularly around watermelon hills. Our correspondent wrote further of this species and of a related form (probably the granulated cutworm, *Feltia annexa* Treit.) with which it was associated, that it had been a terrible pest in his vicinity during the two years previous, and that in 1901 the insects were notably more numerous than before. He stated that it would have been impossible to have grown a crop like cotton or tobacco on his place that year. Some of the larvæ were remarkably late in transforming to pupæ, this being painfully evident in his melon field.

No positive information concerning damage by this species was reported for a few years thereafter, but there can be no doubt whatever that it was injurious, more or less, during many if not all of the remaining years.

In 1908 this species was observed by Mr. C. H. Popenoe and the writer injuring kale, spinach, and lettuce in June at Norfolk, Va., where it was also associated in every instance of observed injury with the granulated cutworm (*Feltia annexa*).

September 3, 1909, near Poplar Branch, N. C., these cutworms were found by Mr. W. L. McAtee, of the Biological Survey of this department, to be exceedingly numerous in a little truck garden kept by Capt. J. T. Westcott. Single rakes of the fingers over 6 inches of the sandy soil disclosed from 6 to 12 cutworms. He gathered a quart of these for fish bait in a few minutes. Cantaloupe and watermelon vines were entirely defoliated and corn and tomatoes were slightly attacked.

March 22, 1910, Mr. F. A. Johnston examined a field of about 3 acres of cultivated dandelions on the farm of Mr. Bruce Carney, at Churchland, Va., and found it badly infested with cutworms of this species. Hidden in the dead leaves around the base of some plants there were as many as 5 or 6 young larvæ. Some were quite small, and no appreciable damage had been done to the crop up to that date by this pest. The winter had been severe on the dandelions, most of them being killed back to the ground, but since the warmer weather set in the plants had made quite rapid growth and were in very fair condition. The crop was being cut for market and it seemed quite probable that a thorough spraying of the leaves that remained after the crop was harvested with either arsenate of lead or Paris green would control the pest.

Some of the larvæ obtained from this source were kept for rearing in this bureau. The first adult issued May 20, and others transformed to moths September 15 and 20.

During the first days of September, 1910, in an extremely heated spell, this species attracted attention on the farm of Mr. B. C. Haines, near Shelton, Va. Mr. Haines was advised to use arsenate of lead at the rate of 4 pounds in 50 gallons of water, and when the writer visited the infested locality a few days later he found that this remedy was producing excellent results. It should be mentioned that on Mr. Haines's farms truck plants are grown in alternate years, so as to produce four alternate crops. In this case parsley, growing between rows of lettuce, was badly affected. As soon as the lettuce was cut for market parsley began to appear and was cut off by the worms even with the ground, so that only a few plants could be seen here and there. The farm is being conducted by irrigation, both overhead and by means of hose, and it is probable that the prompt success in the use of arsenate of lead was doubtless due to the fact that the insects were watered, and thus cooled, at night and heated again by the extremely hot weather occurring during the day. It was found impossible to trace the occurrence of this species earlier in the season, and it was finally agreed between Mr. Haines and the writer that in all probability the cutworms had been introduced with stable manure grown up freely with grass and weeds which had been used when the lettuce and parsley were first planted. They could not have come from any outside source or from any earlier crop. The success of Mr. Haines in his treatment of this pest is shown in the accompanying abstract from his letter.

RESULTS FROM APPLICATIONS OF ARSENATE OF LEAD.

NORFOLK, VA., *November 18, 1910.*

I received your letter of the 16th instant, in regard to the cutworms on my parsley and the ravages of the army worm in this section this fall. As you remember, I had a hard fight with the cutworms on my parsley field, but I feel fully compensated for my work and expense in fighting them. I had several places in each bed where I had to reset plants where the cutworms cut them off, but aside from those few spots I have a perfect stand and am now marketing my crop, and I wish you could see that crop. The best outlook I have ever had.

I kept constantly spraying my parsley with arsenate of lead (4 pounds to 50 gallons of water), and in all I think I gave it five applications. * * *

B. C. HAINES.

It should be added to the above that a careful survey of the infested field by the author showed plainly that an arsenical was the only remedy that could be conveniently used after the outbreak was at its height. It should be added also that the arsenate of lead was not applied five successive times on the same plants.

DESCRIPTION.

The moth.—The moth of this species is quite unlike any common form which inhabits the North Atlantic region, being much paler in color. The forewings are gray, with a pinkish tinge in fresh specimens. There is a submedian dark spot and a row of spots in the form of a curve in the outer third of the wing. The markings are well illustrated in figure 8 (above). It will be noted that the hindwings, which are silvery whitish and are more or less tinged on the outer edges with gray, are considerably shorter. The thorax is of about the same color as the fore wings and nearly uniform throughout. The anterior portion of the abdomen is white and the posterior portion, sometimes a little more than half, is gray. The lower surface is pale, with the fore wings more or less suffused anteriorly with fuscous. The posterior legs are distinctly tessellated. The abdomen is rather more robust than in many related forms, being narrower in the male. The wing expanse is 1½ inches and the length of the body is about five-eighths of an inch.

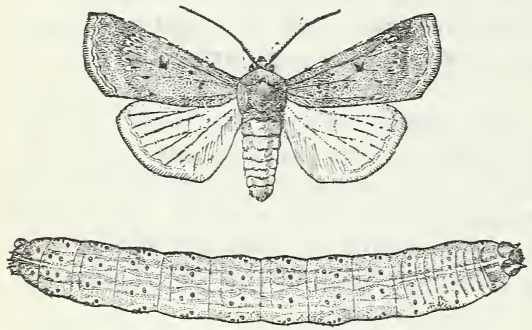

FIG. 8.—*Porosagrotis vetusta:* Moth and larva.

The eggs and earlier stages of the larva have not been studied to the writer's knowledge.

The larva.—The larva is subject to considerable variation, which may be dependent on the soil. Specimens received from North Carolina, in a very sandy soil, are pale, with a decidedly pinkish tinge. The arrangement of the tubercles is shown in figure 8, as is also the form of the thoracic plate. The larva, when alive and when fully matured, measures about 1½ inches, but the inflated specimens run as high as 2 inches in length.

No specimens of the pupa have been preserved for description.

DISTRIBUTION.

All of the specimens of this species in the United States National Museum are from New York State, and are labeled as follows:

Albany, Long Island, Carver, Rochester, and Franklin County, N. Y.

There are also specimens of what appear to be races of this species, one of them being labeled *Porosagrotis satiens*, from Coleville, Wash., Glenwood Springs, Colo., and from Arizona, and a second

species labeled *P. catenula* Grote, from Los Angeles, Cal., Glenwood Springs, Colo., Phoenix, Ariz., and Kaslo, British Columbia.

We have reared *Porosagrotis vetusta*, which displays only slight variation as compared with many other forms of cutworm moths, from Shelton, Churchland, and Norfolk, Va., Rocky Ford, Colo., and Southern Pines, N. C. Another locality is Poplar Branch, N. C.

In 1895 Slingerland[1] mentioned this species in connection with other climbing cutworms under the name of the "spotted-legged cutworm," stating that it occurred in Erie, Lewis, and Monroe Counties, N. Y. Less than 2 per cent, however, of the climbing cutworms received from western New York in 1893 and in 1894 belonged to this species. Beyond the fact that it was found on peach buds, nothing was then known of its habits. The larvæ and moth were figured.

NATURAL ENEMIES.

This species no doubt has many natural enemies. The following, however, are the only ones at present known, both being parasitic:

Apanteles n. sp., near *agrotidis*, issued from larvæ of this cutworm received from North Carolina, May 18, 1901. Determined by Ashmead.

Linnæmya picta Meig., a tachina fly, issued from the second lot, from North Carolina. It was identified by the late D. W. Coquillett. The same species of tachina fly was reared from this cutworm from material received from Norfolk, Va., the flies issuing October 8, 1910.

[1] Bul. 104, Cornell University Experiment Station, pp. 570–571.

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PAPERS ON INSECTS AFFECTING VEGETABLES.

ARSENITE OF ZINC AND LEAD CHROMATE AS REMEDIES AGAINST THE COLORADO POTATO BEETLE.

By Fred A. Johnston, *Entomological Assistant.*

[In cooperation with the Virginia Truck Experiment Station.]

SPRAYING EXPERIMENTS WITH ARSENITE OF ZINC AND LEAD CHROMATE IN COMPARISON WITH OTHER ARSENICALS.

In May, 1911, a series of experiments for comparing the insecticidal value of arsenite of zinc and of lead chromate with that of other arsenicals in controlling the Colorado potato beetle (*Leptinotarsa decemlineata* Say) was undertaken under the direction of Dr. F. H. Chittenden at the Virginia Truck Experiment Station, at Norfolk, Va.

The season was later than usual, making it unnecessary to spray for the potato beetle until about May 9. At this date no larvæ were present on the plants, though beetles and egg masses were abundant.

On May 9 six plats were sprayed. Table I gives the insecticides and strengths used.

Table I.—*Sprays used against the Colorado potato beetle, Norfolk, Va., May, 1911.*

Plat No.	Insecticide used.
I	Lime-sulphur, 2 pounds to 50 gallons of water and 3 pounds of arsenate of lead.
II	Arsenate of lead, 3 pounds to 50 gallons of water.
III	Lead chromate, 2 ounces to 4 gallons of water.
IV	Arsenite of zinc, 1½ pounds to 50 gallons of water.
V	Bordeaux mixture (4–6–50 formula) and 1½ pounds of Paris green.
VI	Bordeaux mixture (4–6–50 formula) and 1½ pounds of arsenite of zinc.

On May 22 all of the potatoes were resprayed, the same proportions of the different materials being used with the exception of the lead chromate in which case the strength was doubled. (One ounce to a gallon of water.)

At this date the larvæ were exceedingly numerous and doing much damage in unsprayed potato fields.

On the day following the second application of the sprays a count of the infested plants in each plat was made and the following figures obtained:

TABLE II.—*Results of spray applications against the Colorado potato beetle, Norfolk, Va., May, 1911.*

Plat No.	Insecticide used.	Number of infested plants.	Number of uninfested plants.	Infestation.
				Per cent.
I	Lime-sulphur (2–50 formula) and 3 pounds of arsenate of lead	37	347	9.6
II	Arsenate of lead, 3 pounds to 50 gallons of water	118	622	15.9
III	Lead chromate, 2 ounces to 4 gallons of water, and 1 ounce to 1 gallon of water	216	169	+56.0
IV	Arsenite of zinc, 1½ pounds to 50 gallons of water	206	1,048	16.4
V	Bordeaux mixture (4–6–50 formula) and 1½ pounds Paris green	152	741	+17.0
VI	Bordeaux mixture (4–6–50 formula) and 1½ pounds arsenite of zinc	225	555	28.8

It will be seen that the results obtained from the use of lead chromate were very unsatisfactory as compared with those in the case of other insecticides used. The lead chromate employed was in the form of a powder, and great difficulty was experienced in making it mix well with water, it having a tendency to settle quite rapidly, requiring constant agitation to keep it in solution. It adhered well to the foliage, and its color stood out quite prominently in contrast to the other plats. However, the young larvæ seemed to be able to feed on plants that were thoroughly covered with the material without receiving much injury.

The arsenite of zinc employed was also in the powdered form. It is much lighter than lead chromate and remains in suspension in water much better. It adheres to the foliage very well and does not, so far as could be observed, burn or injure the plants in any way.

The percentage of infested plants in the plat that was treated with Bordeaux mixture and arsenite of zinc was somewhat greater than in the plat in which the arsenite of zinc alone had been used. This was no doubt due partly to the fact that the Bordeaux-arsenite of zinc plat was in a different field, one which had been in potatoes the previous year and was thus subject to the attack of a greater number of beetles. Also, many of the plants which were counted as infested were only slightly injured, and it is doubtful if the yield of potatoes would have been much lessened.

On June 29 the potatoes were dug, and following are the weights of one row of potatoes in each of the first four plats.

TABLE III.— *Yields of potatoes from one row from each of Plats I, II, III, and IV, sprayed as indicated in Table I.*

One row from plat No.	Insecticide used.	Number of plants in row.	Weight of No. 1 potatoes.[1]	Weight of No. 2 potatoes.[2]
			Pounds.	*Pounds.*
I	Lime-sulphur and arsenate of lead	384	188¼	25¾
II	Arsenate of lead	368	172¾	26
III	Lead chromate	385	128	19¾
IV	Arsenite of zinc	374	143½	18

[1] Excellent to good. [2] Fair to indifferent.

By taking the yield of the same number of plants from each row the contrast between the different rows will be more marked. Table IV represents the yield of 374 plants from each row:

TABLE IV.— *Yields of potatoes from 374 plants from one row from each of Plats I, II, III, and IV, sprayed as indicated in Table I.*

One row from plat No.	Insecticide used.	Number of plants in row.	Weight of No. 1 potatoes.[1]	Weight of No. 2 potatoes.[2]
			Pounds.	*Pounds.*
I	Lime-sulphur and arsenate of lead	374	183.26	25.05
II	Arsenate of lead	374	175.401	26.18
III	Lead chromate	374	124.168	19.07
IV	Arsenite of zinc	374	143.5	18

[1] Excellent to good. [2] Fair to indifferent.

SPRAYING EXPERIMENTS WITH ARSENITE OF ZINC AT VARIOUS STRENGTHS.

An experiment with the three following strengths of arsenite of zinc in controlling the Colorado potato beetle was begun at the Virginia Truck Experiment Station, Norfolk, Va., on May 31, 1911.

No. I, arsenite of zinc, 1 pound to 50 gallons of water.
No. II, arsenite of zinc, 1½ pounds to 50 gallons of water.
No. III, arsenite of zinc, 2 pounds to 50 gallons of water.

On the day the spraying was done (May 31) the rows sprayed with No. I, No. II, and No. III had 47, 86, and 88 infested plants, respectively.

On June 2 the row treated with No. I had 33 infested plants, a decreased infestation of 14 plants, or 29.8 per cent. The row treated with No. II had 57 infested plants, a decreased infestation of 29 plants, or 33.7 per cent, while the row treated with No. III had 38 infested plants, a decreased infestation of 50 plants, or 56.8 per cent.

On June 3 the count was again taken, and the row treated with No. I had 15 infested plants, a decreased infestation of 32 plants, or 68+ per cent. The row treated with No. II had 23 infested plants, a decreased infestation of 63 plants, or 73.2 per cent, while the row treated with No. III had 13 infested plants, a decreased infestation of 75 plants, or 85.2 per cent.

The following table shows the number of infested plants in the plats before and after spraying:

TABLE V.—*Results of applications of arsenite of zinc at different strengths against the Colorado potato beetle.*

Date.	Solution No.	Number of infested plants.	Decrease in number of infested plants.	Decrease of infestation.
1911.				*Per cent.*
May 31	I	47		
Do	II	86		
Do	III	88		
June 2	I	33	14	29.8
Do	II	57	29	33.7
Do	III	38	50	56.8
June 3	I	15	32	68+
Do	II	23	63	73.2
Do	III	13	75	85.2

On June 3 the number of larvæ on the plants which were still infested was much smaller than the number present when the spray was first applied. The extent of infestation of some plants amounted to but one or two larvæ; these plants, however, were counted in as infested.

Results.—From the preceding table it will be seen that far better results were obtained where 2 pounds of arsenite of zinc to 50 gallons of water were used.

The results were obtained more quickly, and a larger percentage of larvæ was killed. At this strength arsenite of zinc did not burn or injure the foliage in any way, and without doubt an even greater amount of the arsenical might be used without injury to the plants and with correspondingly greater efficiency in killing the beetles.

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PAPERS ON INSECTS AFFECTING VEGETABLES.

A REPORT OF PROGRESS REGARDING THE SUGAR-BEET WEBWORM.

(*Loxostege sticticalis* L.)

By H. O. Marsh,
Entomological Assistant.

INTRODUCTION.

During portions of the years 1909 and 1910 and nearly all of 1911 the writer, stationed in the Arkansas Valley of Colorado and Kansas, was engaged in a study of the insects affecting sugar beets and truck crops. Among the foremost of the species of insects studied was the sugar-beet webworm (*Loxostege sticticalis* L.). Although the investigation of this pest has not been completed, control measures have been fairly definitely worked out, and this preliminary article is presented with the hope that it will stimulate greater interest in the subject among the beet growers, and thus render the completion of the study more easily accomplished.

Sugar beets have been produced on a commercial scale in the Arkansas Valley since 1900, and almost from the beginning this crop has been infested by webworms. The injury produced by these infestations has varied greatly from year to year. During some seasons little noticeable damage has occurred, while on a few occasions the infested acreage has been extensive and the losses serious. As an example it may be mentioned that in 1910 practically 4,000 acres of beets grown for one of the sugar factories in the Arkansas Valley were attacked. The serious nature of this outbreak was not realized until too late, and although strenuous efforts were finally made to control the "worms," the loss resulting from this infestation was estimated at 20,000 tons of beets, which would have been worth approximately $100,000 to the growers. Such severe losses are rather exceptional, although nearly every year the loss occasioned by webworms is far in excess of the amount imagined by the average beet grower.

To the progressive farmers in the Arkansas Valley the sugar-beet webworm is generally too well known to require a detailed description, although a few notes regarding the life history when infesting sugar beets may be of value.

GENERAL APPEARANCE OF THE SUGAR-BEET WEBWORM AND NATURE OF ATTACK.

The parent of this webworm (fig. 9) belongs to the lepidopterous family Pyralidæ, and is a tawny-brown, active moth, or "miller," with a wing expanse of about 1 inch.

It is larger and more conspicuously colored than the garden webworm which is shown in figure 10.

FIG. 9.—The sugar-beet webworm (*Loxostege sticticalis*): Moth. Twice natural size. (Reengraved after Insect Life.)

The moths deposit their pearly-white eggs singly or in rows of from two to five or more, usually on the under side of the leaf. When deposited in rows they overlap more or less. Each female moth is capable, under normal conditions, of depositing at least 200 eggs. From these eggs hatch the small larvæ, or "worms." When first hatched the "worms" are whitish, with black heads, but as they feed and increase in size they become green, with dark markings. The very young larvæ eat small holes in the under side of the leaves without, however, cutting through the upper epidermis, but as they increase in size they consume almost the entire leaf, with the exception of the larger veins and the petioles. The "worms" prefer the older leaves, and unless the food supply is nearly exhausted do not eat the young leaves at the center of the plant. When full grown the "worms," which are slender and about an inch in length, leave the beets and burrow in the soil, usually close about the infested plants, and spin tubelike cases in which they later pupate. The pupæ are slender, yellow-brown, inactive objects, from which during the summer months the moths issue within a few days. The moths, after issuing, feed on the nectar in alfalfa or other blossoms and within a few days mate and are ready to commence depositing eggs for another generation or brood of "worms."

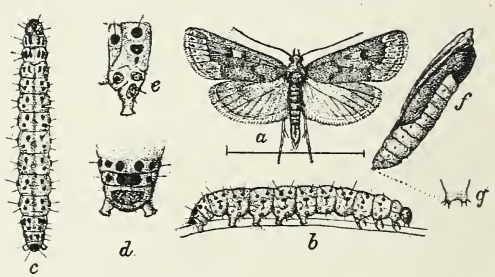

FIG. 10.—The garden webworm (*Loxostege similalis*); *a*, Male moth; *b*, larva, lateral view; *c*, larva, dorsal view; *d*, anal segment; *e*, abdominal segment, lateral view; *f*, pupa; *g*, cremaster. *a*, *b*, *c*, *f*, somewhat enlarged; *d*, *e*, *g*, more enlarged. (After Riley, except *c*, from Chittenden.)

LIFE HISTORY AND HABITS.

In rearing experiments conducted at Rocky Ford, Colo., the average time required from the deposition of the eggs until the moths issued was a little more than a month. The egg stage was observed to vary from 3 to 5 days, the larva stage from 17 to 20 days, and the pupa stage was usually 11 days. These variations were from records of successive generations.

So far as the writer has been able to determine, there are three generations or "crops" of webworms in the Arkansas Valley each year. There may be a fourth generation, but if so it is not clearly marked and possibly occurs early in the season on weeds such as Russian thistle (*Salsola tragus*) and lamb's-quarters (*Chenopodium album*). For the sake of convenience we may assume that only three generations occur yearly. The periods during which the writer observed the webworms of these successive generations in evidence on sugar beets in the Arkansas Valley ranged from about the middle of June until early July for the first generation and from about the middle of July until well into August for the second generation, while the third brood occurred in September.

In reality the generations are not sharply marked and considerable overlapping may occur. In general the danger period extends from shortly before the middle of June until well into September. The first generation of webworms may be expected at its height of destructiveness during the latter half of June, at a time when the beets are comparatively small and least able to resist the attack. (See fig. 14.) At this season the infested beets may actually be killed by this webworm, which, after eating all the leaves, may destroy the crown of the plant. Whenever the crown is destroyed the beet dies. So far as the writer has observed, the acreage destroyed in this way is very small and ordinarily occurs only when the infested beets are young and the available leaf surface limited. By the time the "worms" of the later generation are present the beets have become of good size and, although they may be completely stripped of all but the youngest leaves, it is rarely that any are killed. (See figs. 11, 12.)

The larvæ of the first generation, after maturing and burrowing into the ground, pupate promptly and the moths issue within a few days and deposit eggs for the second generation. The "worms" of this next generation, on reaching maturity, likewise burrow into the ground and spin their tubelike cases. However, only about half of them pupate promptly, the others remaining unchanged in the tubes until the spring of the following year. From the pupæ which develop in August, moths issue which deposit eggs for the third or September generation, and these "worms" remain unchanged throughout the

winter. It will thus be seen that about half the webworms of the second generation and all of those of the third generation, which have not been destroyed by parasites or through artificial or natural agencies, live through the winter in their tubes in the soil. These "worms" pupate late in the spring and the moths which issue deposit eggs for the first generation.

The moths when depositing eggs are often to be found in the beet fields in enormous numbers, and when disturbed may be seen flying close above the beet leaves in "clouds." When such numbers of moths are observed in a beet field they should serve as a warning to the

FIG. 11.—A medium sized sugar-beet plant defoliated by the sugar-beet webworm in July. (Original.)

grower that a "crop" of webworms may be expected within the next week or 10 days.

As a rule the first and second generations are the most destructive, the third generation, which is actually only a partial one, rarely causing serious damage. It seldom happens that the "worms" of successive generations infest the same patch of beets to a serious extent. Thus a certain field may be infested by the webworms of the first generation, while the moths which develop from them may drift to adjoining fields to deposit eggs for the next generation.

The webworms often appear very suddenly and apparently without warning in certain fields, and it is not uncommon for the growers to express the idea that they have migrated from adjoining fields.

This, however, is not the case, but their apparently sudden appearance is explained by the fact that the young webworms are easily overlooked and that during the last few days before they reach maturity their growth is very rapid. It frequently happens that from 50 to 300 eggs are deposited on single beet plants, and in extreme cases as many as 500 eggs may be so placed. The worms hatching from these eggs remain upon the beet on which they hatched until they reach maturity, unless all the leaves are destroyed and they are thus forced to crawl to another beet to obtain food.

FIG. 12.—Sugar beets defoliated by the sugar-beet webworm in July. (Original.)

CHARACTER OF INJURY.

It is impossible to state definitely the damage to sugar beets that an infestation of webworms may cause, as this may vary from almost no perceptible loss to the complete destruction of the infested plants, the extent of the injury depending on the number of webworms present, the size of the infested beets, and various other factors, such as climatic conditions, soil fertility, and water supply. As previously mentioned, small beets may be killed outright (see fig. 14), while larger beets may be completely stripped of foliage. With large beets new leaves will usually be put out promptly and their apparent recovery will take place quickly, especially if they are irrigated as soon as possible after the defoliation. Although new leaves are soon put out, defoliation retards the growth of the beet roots. (See fig. 13.) The writer has seen beet roots which at the time the tops were defoliated, in early July, were more than an inch in greatest diameter that made absolutely no gain in weight or size for three weeks after the leaves were destroyed. It might be added that these beets were in good, fertile soil and were watered

even while the webworms were destroying the foliage. Judging from personal observations and from the statements of many growers, the writer may state that when sugar beets have been defoliated by webworms during the growing season a loss of from 1 to 5 tons of roots to the acre may be apparent at harvest time. The decrease in tonnage is not the only damage, as analyses of such beets have indicated losses of both sugar content and purity, which in some cases have reduced the price $1 a ton. Another injurious feature which follows defoliation is that the soil about the beets is exposed to the direct rays of the sun, allowing the moisture to evaporate rapidly, and if the supply of irrigation water is limited this may become a serious matter.

FIG. 13.—Large sugar-beet plants, showing defoliation and weakened roots due to attack by the sugar-beet webworm in August. (Original.)

It will be seen that the sugar-beet webworm is a pest capable of causing extensive damage and that measures tending toward its control are worthy of careful consideration.

NATURAL ENEMIES.

Fortunately this species has natural enemies, among the most efficient of which are blackbirds. These birds often gather in enormous flocks in the infested beet fields and feed on the webworms. Unfortunately the webworms are not thus attacked until they have become nearly full grown and attain a size that renders them more conspicuous. As a result, it generally happens that the infested beets are partially or completely defoliated before the birds have completed their good work. The destruction of the "worms," however, lessens the possible number of the succeeding generation. The webworms are also reduced in number by true parasites, and in some cases the writer has found fully 50 per cent of the overwintered larvæ killed in this way. One of the most common parasites is a little wasplike insect known scientifically as *Diosphyrus vulgaris* Cress., a braconid.

OTHER CHECKS.

As previously noted, the webworms burrow into the soil about the infested plants, and when the beets are plowed out at harvest time many of the worms are crushed or are so deeply buried that the moths, if they succeed in developing, are unable to leave the tubes, and consequently perish. In spite of these checks there will be every year some areas of greater or less extent where the webworms will occur in injurious numbers and where spraying or other artificial control measures will be necessary.

FIG. 14.—Field of young sugar beets destroyed by the sugar-beet webworm in late June. (Original.)

EXPERIMENTS WITH REMEDIES.

During the time the writer has been stationed in the Arkansas Valley he has given special attention to means of controlling this webworm, and in his opinion spraying with Paris green has proven by far the most effective and satisfactory remedy. The writer has made many experimental tests with a variety of insecticides and has also supervised a considerable amount of practical work against this species, as a result of which study he considers the following formulas as most efficient:

Formula No. 1.

Paris green	pounds	3
Whale-oil soap	do	6
Water	gallons	100

Formula No. 2.

Paris green	pounds	3
Lime	do	3
Water	gallons	100

These mixtures have been applied to sugar beets with various types of sprayers (figs. 15–22) at the rate of from 80 to 125 gallons per acre, and the results have been uniformly successful in controlling the webworms. As a rule, 100 gallons per acre should be applied and the spraying commenced as soon as possible after the webworms have hatched. Where possible the spray should be applied at about 80 pounds pressure, although the writer has observed good results where only 40 to 50 pounds pressure was maintained. The leaves of sugar beets are quite smooth, and in order to apply an even coat of poison it is necessary to add some adhesive to the spray mixture. In the writer's experience nothing has proven more satisfactory for this

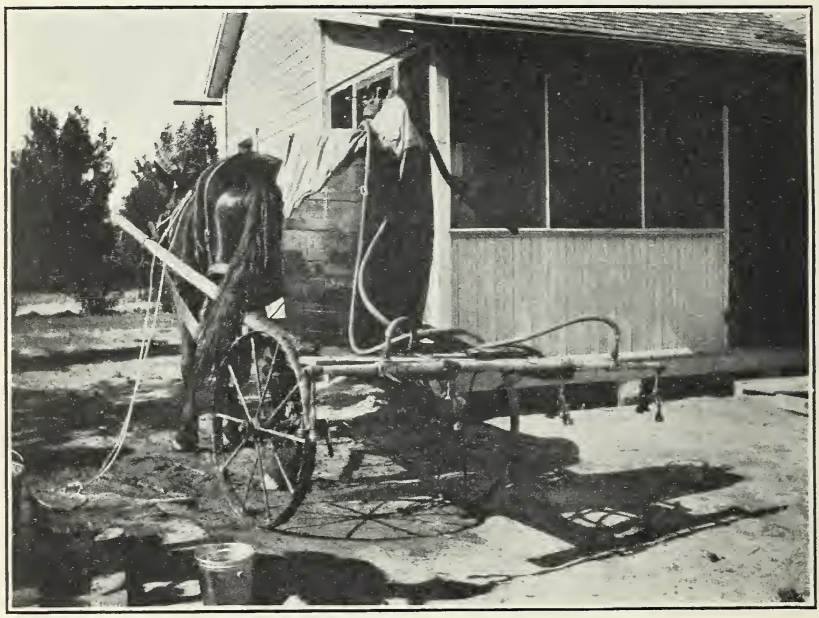

FIG. 15.—Barrel sprayer suitable for use against the sugar-beet webworm. (Original.)

purpose than whale-oil soap. If it is not obtainable, ordinary laundry soap may be used with about equally beneficial results, although it is more expensive. Lime, as recommended in formula No. 2, serves to an extent as an adhesive and has the additional effect of neutralizing any free arsenic which may be present in the Paris green. Lime, however, renders the mixture somewhat caustic, and this formula is less pleasant to use than is one in which soap is used as the adhesive agent.

Refuse molasses from the beet-sugar factories was given extensive tests as a substitute for soap, and when used at the rate of from 3 to 6 gallons in 100 gallons of mixture it served as an effective adhesive. The molasses, however, contains a considerable amount of

alkali and other impurities which tend to make soluble some of the arsenic and copper in the Paris green. The soluble arsenic burns the beet foliage, and on account of this injury refuse molasses is not recommended. It may be interesting to add that in experiments which the writer made with Paris green against other species of insects, using as an adhesive refuse molasses from cane mills, which was less highly charged with impurities, the results were satisfactory, and no burning of the sprayed foliage occurred.

Several standard brands of arsenate of lead have been tested against the sugar-beet webworm in the Arkansas Valley, and with-

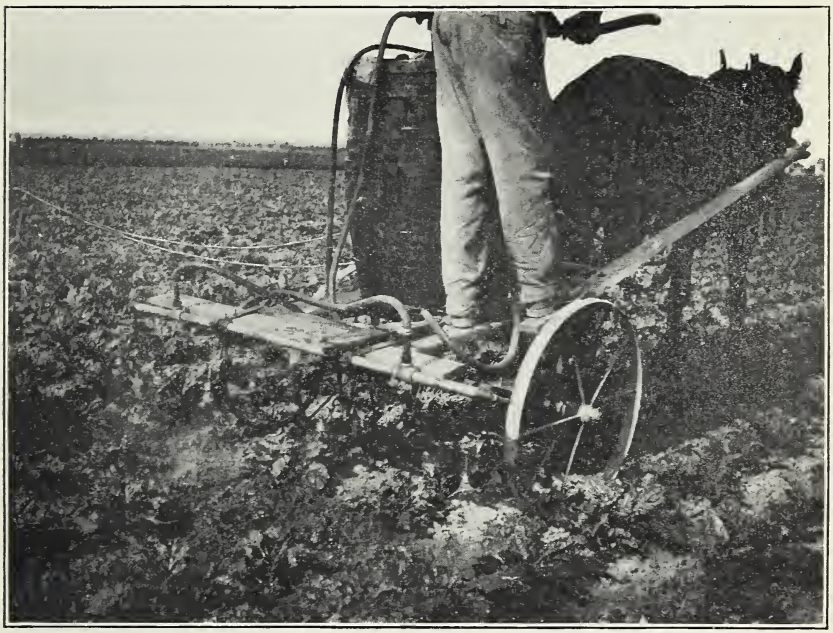

FIG. 16.—Barrel sprayer in action against the sugar-beet webworm. (Original.)

out exception the results have proven unsatisfactory. The arsenate was used at the rate of 6, 8, and 10 pounds in 100 gallons of water, and 100 gallons per acre applied, but the webworm was not controlled. In these experiments a large traction sprayer and an ordinary barrel sprayer were used.

Zinc arsenite, when used at the rate of 4 pounds in 100 gallons of water and applied at the rate of 125 gallons per acre, was effective. It was, however, noticeably slower in its killing effects than Paris green as recommended in formulas Nos. 1 and 2, and when used at this strength was equally as expensive as an effective application of Paris green.

Paris green will kill the sugar-beet webworm when used at the rate of 2 pounds in 100 gallons of water, but its action is comparatively slow. It can also be safely used on sugar beets at the rate of 4 pounds in 100 gallons of water, although this amount is excessive and unnecessarily expensive. All things considered, either formula No. 1 or formula No. 2 can be depended on for the most satisfactory results.

Many beet growers demand that an insecticide to be used against webworms shall be immediately effective. It is of course unreasonable to expect immediately fatal results from a stomach poison. When Paris green is properly applied against this webworm at the rate of 3 pounds in 100 gallons of water, a fairly large number of dead webworms will be found about the sprayed beets at the end of 24 hours, and at the end of three days practically all webworms should be dead.

Dusting with Paris green and lime has also proven effective against this webworm when used at the rate of from 2 to 4 pounds of the poison in 100 pounds of air-slaked lime. The "dust" may be applied by shaking it from a coarse sack or with a "powder gun." This method is slow, would increase the cost of application more than 50 per cent, and is difficult to apply in an even coating.

Occasionally a field of beets may have been irrigated just before an infestation of webworms becomes apparent, and in such a case the soil is likely to be so wet that the prompt use of a sprayer will prove impracticable and dusting may then be employed to advantage.

SPRAYING MACHINERY.

For spraying large areas of sugar beets a geared traction sprayer of 125 gallons' capacity (figs. 20–22) will prove profitable; but for the average grower, whose planting does not exceed 20 acres, this type of machine is too expensive and unnecessarily large, and a smaller, much cheaper sprayer, which can be assembled at home, will give satisfactory results. Such a sprayer may be fitted up by mounting a spray pump in a 50-gallon barrel on an ordinary one-horse, two-row beet cultivator, from which the "handles" and "shoes" have been removed. This arrangement will be readily understood by referring to the accompanying illustrations (figs. 15, 16). The four-row attachment is connected with the pump by a rubber hose and is fastened to sections of plank which are bolted to the cultivator frame and extend out behind the wheels. The row attachment is made of $\frac{3}{8}$-inch and $\frac{1}{4}$-inch iron pipes and can be put together by a plumber. Three types of row attachments are illustrated. Number 1 (fig. 17) is the simplest and will give satisfaction under ordinary conditions. This may be built to cover eight rows of beets instead of four. The eight-row attachment, however, is rather cumbersome

and may cause some trouble by catching in fences, etc., when turning at the end of the field. Number 2 (fig. 18) is so arranged that two nozzles are above each row of beets. This is desirable, but not

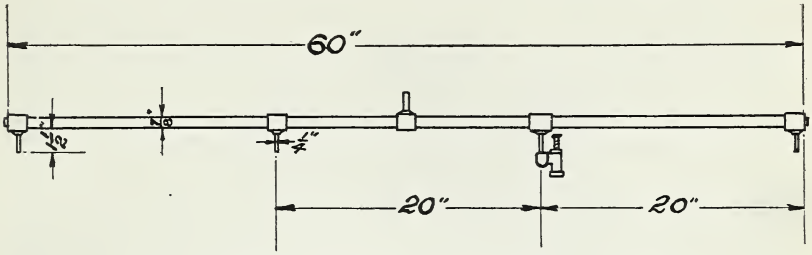

FIG. 17.—Four-row attachment for beet sprayer. (Original.)

absolutely necessary, when large beets are to be sprayed. Number 3 (fig. 19) is so made that both the surface and the underside of the beet leaves are reached by the spray. By using this attachment

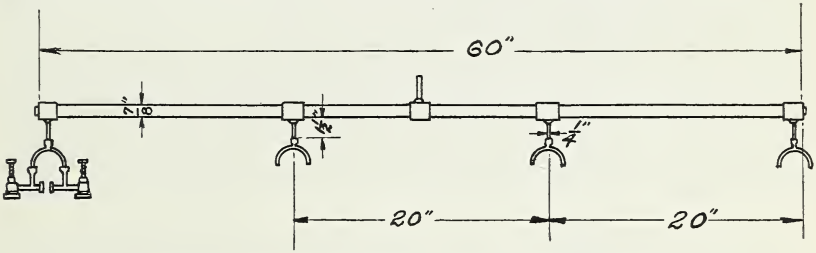

FIG. 18.—Four-row attachment for beet sprayer. (Original.)

beets can be very thoroughly sprayed and young webworms on the underside of the leaves will be more quickly killed than when only the surface of the foliage is wet by the spray. A nozzle arrange-

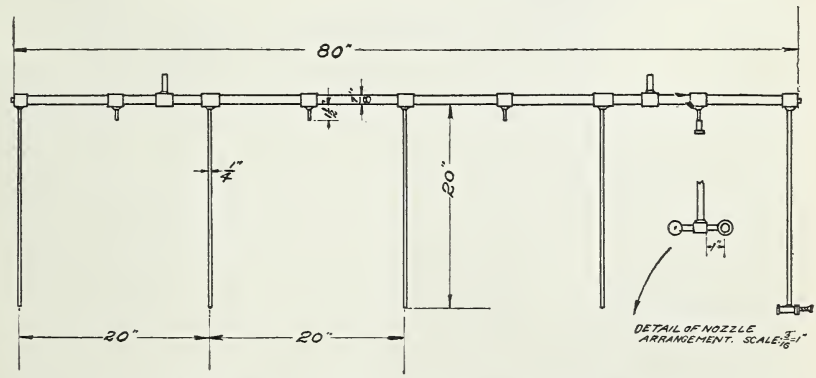

FIG. 19.—Four-row attachment for beet sprayer; Nozzles arranged so that both the upper and lower sides of the leaves may be wet by the spray. (Original.)

ment such as is obtained with this type is necessary when Bordeaux mixture is applied for the leaf-spot disease (*Cercospora beticola* Sacc.).

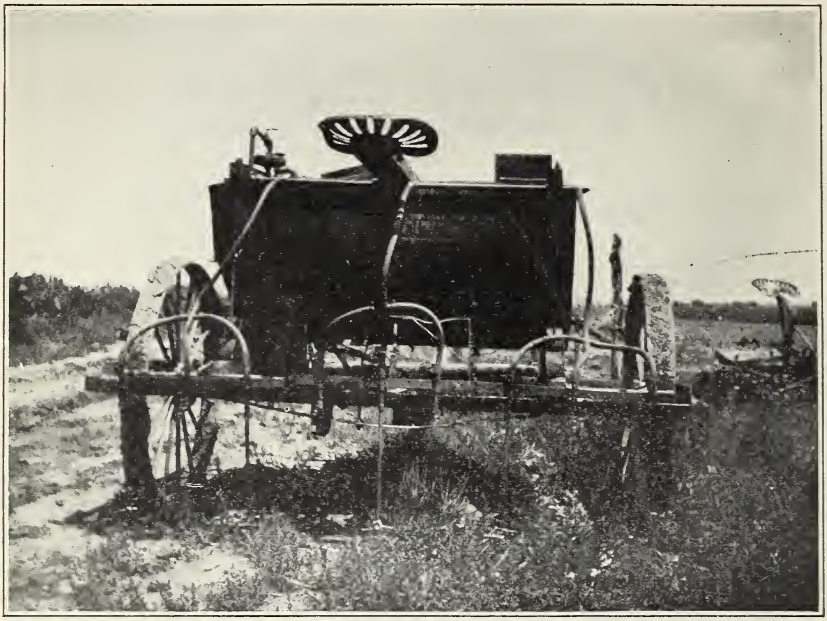

FIG. 20.—Geared traction sprayer suitable for use against the sugar-beet webworm. (Author's illustration.)

FIG. 21.—Geared traction sprayer in action against the sugar-beet webworm. (Author's illustration.)

In fitting up a sprayer a strong, heavily built pump provided with an agitator should be used, and the necessity of using first-class nozzles is imperative. The nozzles should be of the Vermorel type

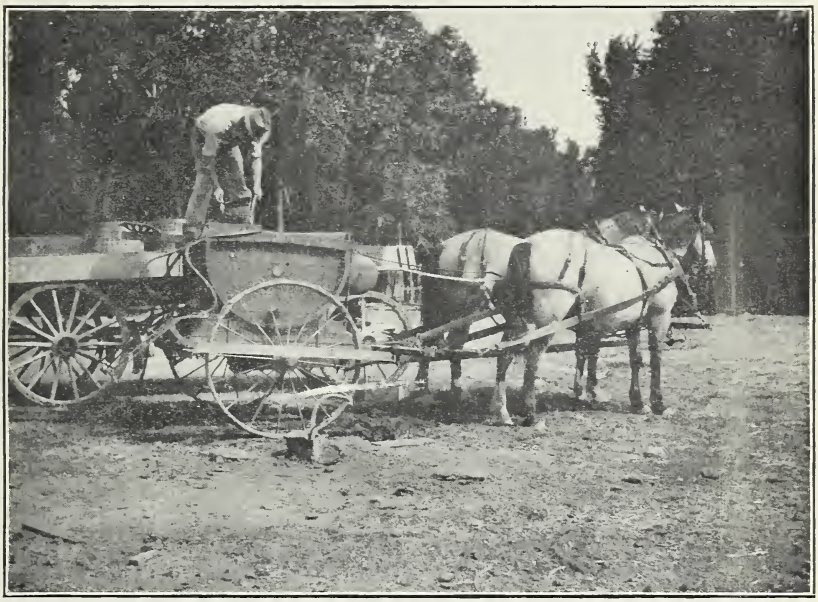

FIG. 22.—Filling a traction sprayer for spraying against the sugar-beet webworm. (Original.)

(fig. 23), which delivers a fine, mistlike spray. This type of nozzle, together with the pump, hose, and other fittings, can be purchased from any reliable dealer, and the entire sprayer can be fitted up at an expense not exceeding $25.

With this sprayer and a horse it is easily possible for one man to spray 5 acres of sugar beets a day. With a large traction sprayer a much greater acreage may be treated in the same length of time.

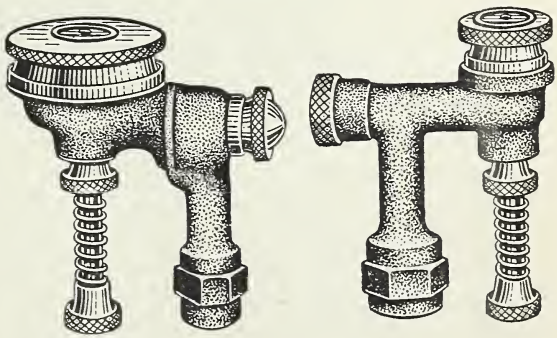

FIG. 23.—Type of Vermorel nozzles suitable for spraying sugar beets against the sugar-beet webworm.

COST OF SPRAYING.

The cost of labor, materials, etc., for spraying sugar beets will vary under ordinary circumstances from $1 to $2 an acre. The price received for sugar beets by the growers in the Arkansas Valley

usually exceeds $5 a ton. As previously mentioned, a defoliation by the sugar-beet webworm may reduce the yield of sugar beets 1 to 5 tons to the acre and also cause a loss in sugar content and purity. As this damage can be absolutely prevented at a cost not exceeding $2 an acre, the profits from spraying infested beets are apparent.

CONCLUSION.

An easily accessible supply of water will aid materially in keeping down the cost of spraying. Water from the irrigation laterals may be used, but in all cases it should be carefully strained to prevent dirt and other material from getting into the pump and clogging the nozzles. Water that is highly charged with alkali should be avoided.

After a sprayer is used it should be carefully washed with clean water and all the working parts thoroughly oiled. It is a mistake to allow a sprayer to stand in the field exposed to sun and weather, and it will pay to keep it housed when not in actual use.

As a final word, it may be well to state that webworms, and with few exceptions most other insects which affect sugar beets in the Arkansas Valley, can be easily and cheaply controlled. When this fact is more generally accepted by the beet growers it is safe to say that sugar beets will produce still better profits.

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PAPERS ON INSECTS AFFECTING VEGETABLES.

THE HORSE-RADISH WEBWORM.

(*Plutella armoracia* Busck.)

By H. O. Marsh,
Entomological Assistant.

INTRODUCTION.

At Rocky Ford, in the Arkansas Valley of Colorado, horse-radish is grown on a very limited scale for home use. Among the insect enemies of this vegetable are a flea-beetle, *Phyllotreta pusilla* Horn, the spinach aphis (*Myzus persicæ* Sulz.), the common cabbage worm (*Pontia rapæ* L.), the southern cabbage worm (*Pontia protodice* Boisd.), the diamond-back moth (*Plutella maculipennis* Curtis), and the horse-radish webworm (*Plutella armoracia* Busck). This latter species is a new and hitherto unrecorded truck-crop pest. As nothing has been published regarding its life economy the author has drawn up this preliminary article touching its occurrence, life history, habits, and remedies.

OCCURRENCE IN COLORADO.

This species was first found at Rocky Ford by the author during the latter half of April, 1911. At this time larvæ, pupæ, and adults occurred in moderate numbers on horse-radish in one garden. The species was observed in this garden at various dates throughout the spring and summer. The larvæ checked the early growth of the plants somewhat, but no serious damage resulted. In 1912 the overwintered larvæ became active on these plants, which were then just showing above ground during the last days of March.

So far as the author has been able to determine, the infestation is limited to about 15 "clumps" of horse-radish plants in one garden at Rocky Ford. Careful search was made for this species on horse-radish in other gardens at Rocky Ford and on various species of wild and cultivated cruciferous plants in other portions of the Arkansas Valley, but without success. The infested horse-radish plants

have been in their present location for several years and it is impossible to determine their origin or whether they were infested when planted in the garden mentioned.

GENERAL APPEARANCE AND HABITS.

The horse-radish webworm (fig. 25) is a beautiful, slender moth belonging to the lepidopterous family Yponomeutidæ. The wings are cream colored with a brownish tinge and have an expanse of about five-eighths of an inch. The moths are shy and hide among the foliage of infested horse-radish plants. When disturbed they fly readily for a short distance and usually promptly hide. In captivity they feed eagerly on diluted honey.

The eggs (fig. 26, *c*) are scale like and are usually deposited singly on the upper or lower sides of the leaves.

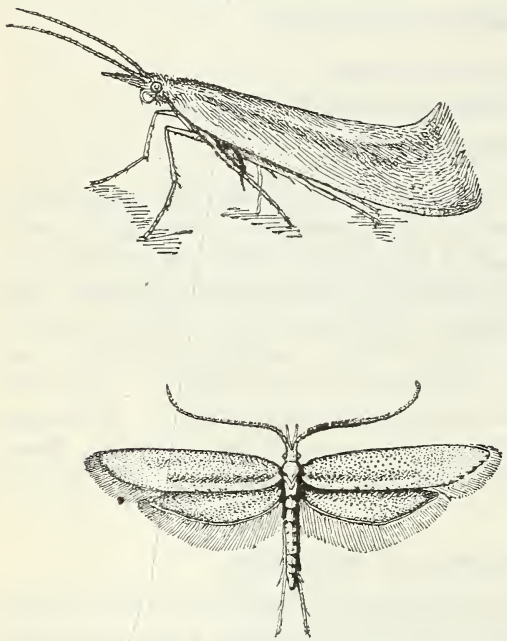

FIG. 25.—The horse-radish webworm (*Plutella armoracia*): Moth, side view, above; moth with wings spread below. Enlarged. (Original.)

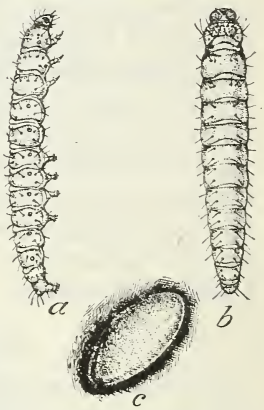

FIG. 26.—The horse-radish webworm: *a*, Larva, lateral view; *b*, larva, dorsal view; *c*, egg. All enlarged. (Original.)

The newly hatched larvæ are pale yellow. The mature larvæ (fig. 26, *a*, *b*) are yellowish green, with a more or less distinct yellow or orange band across the dorsal surface near the middle. Almost immediately after hatching the larvæ spin compact webs under which they rest and feed until mature. The webs are white or gray and are remarkably close-meshed. When the horse-radish plants are young the larvæ web together and feed on the first spikelike leaves and later a favorite location is among the blossom buds. With older plants the larvæ feed on the leaves generally, usually selecting the most tender ones.

Their most noticeable injury is caused by checking the first growth of the plants early in the spring and destroying the blossom buds.

The pupæ (fig. 27) are pale yellow marked with brown and are inclosed in cocoons. The cocoons (fig. 28) are placed on leaf petioles or among dead leaves and are exquisitely beautiful, silver-gray, lace-like, cigar-shaped objects.

LIFE HISTORY.

There are four generations each year and activity is continuous from the last days of March until well into October. A few of the larvæ of the fourth generation mature and produce moths in late September or October, but the majority live through the winter among dead leaves or in cracks in the soil and develop into moths the following April. The hibernating larvæ may vary from very small to nearly mature specimens. The moths are remarkably long lived and egg-laying extends over a considerable period. The generations overlap to such an extent that it is practically impossible to separate them in the field. The details of the generations and stages are given in the rearing records which follow.

FIG. 27.—The horse-radish webworm: Pupa. Greatly enlarged. (Original.)

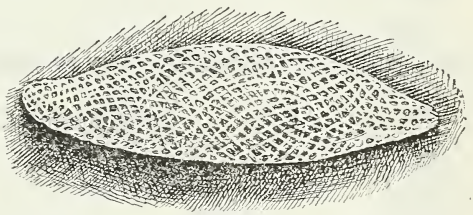

FIG. 28.—The horse-radish webworm: Cocoon. Greatly enlarged. (Original.)

REARING RECORDS.

On April 3 several overwintered larvæ were collected from horse-radish and placed in a cage. The record is as follows:

Apr. 3	Larvæ collected.
Apr. 4	First cocoons formed.
Apr. 6	First larvæ pupated.
Apr. 23	First adults issued.

On April 24 a pair of these moths mated and were placed in a separate cage containing horse-radish leaves and diluted honey. The record is as follows:

First generation.

Apr. 24	Moths mated.
Apr. 25	First eggs deposited.
May 3	First eggs hatched.
May 25	First cocoons formed.
May 26	First larvæ pupated.
June 3	First adults issued.

From the above record the stages are as follows:

	Days.
Egg stage	8
Larval stage	23
Pupal stage	8
Total	39

A pair of these moths mated June 9 and were placed in a separate cage.

Second generation.

June 9	Moths mated.
June 10	First eggs deposited.
June 20	Eggs hatched.
July 5	First cocoons formed.
July 6	First larvæ pupated.
July 17	First adults issued.

From the above record the stages are as follows:

	Days.
Egg stage	10
Larval stage	16
Pupal stage	10
Total	36

A pair of these moths mated July 24 and were placed in a separate cage.

Third generation.

July 24	Moths mated.
July 26	First eggs deposited.
July 31	Eggs hatched.
Aug. 12	First cocoons formed.
Aug. 13	First larvæ pupated.
Aug. 21	First adults issued.

From the above record the stages are as follows:

	Days.
Egg stage	5
Larval stage	13
Pupal stage	8
Total	26

A pair of these moths mated August 24 and were placed in a separate cage.

Fourth generation.

Aug. 24	Moths mated.
Aug. 25	First eggs deposited.
Sept. 1	Eggs hatched.
Sept. 26	First cocoons formed.
Sept. 28	First larvæ pupated.
Oct. 11	First adults issued.

From the above record the stages are as follows:

	Days.
Egg stage	7
Larval stage	27
Pupal stage	13
Total	47

Only a few adults of the fourth generation issued during October, and these deposited no eggs. The majority of the larvæ of this generation went into hibernation about the middle of October. These larvæ will hibernate among dead leaves and in cracks in the soil and develop moths during April of the following spring. It will thus be seen that the larval stage of the fourth generation may vary from 27 days to 6 months.

EGG-LAYING RECORD.

On May 3 a female issued and mated with a male which had emerged a day earlier. The pair, while still in copulation, was isolated in a cage containing a wad of absorbent cotton saturated with diluted honey and a horse-radish leaf. Eggs were deposited as follows:

	No. of eggs deposited.		No. of eggs deposited.
May 4	29	May 19 and 20	36
May 5 and 6	39	May 21	16
May 7	15	May 22	12
May 8	27	May 23	7
May 9	18	May 24	4
May 10	12	May 25	3
May 11	21	May 26	6
May 12 and 13	15	May 27	8
May 14	7	May 28	3
May 15	13	May 29	3
May 16	13	May 30	3
May 17	9		
May 18	12	Total	331

The moths were observed copulating May 3, 8, 13, and 20. The male died May 28 and the female June 4. The length of life of the male was 26 days and of the female 32 days.

The rearing records were obtained in the laboratory at Rocky Ford, Colo. The cages were placed in a window which was kept open night and day. Food was supplied the moths by putting in wads of absorbent cotton which were saturated with honey and water. This food was eaten eagerly. In the cages the moths were quiet and easily controlled. In all cases the larvæ were fed with horse-radish leaves.

NATURAL ENEMIES.

Only one natural enemy has been found preying on this species at Rocky Ford. This is a small, wasp-like hymenopterous insect which Mr. H. L. Viereck has described as *Angitia plutellæ* n. sp. This parasite is evidently largely responsible for checking the increase of the Plutella larvæ. The adults were found in the field from the latter part of April until the middle of November. In the cages the first adults developed from overwintered Plutella larvæ on April 23 and 27. It is probable that the parasites live through the winter as eggs or larvæ within the bodies of the hibernating Plutella larvæ.

EXPERIMENTS WITH INSECTICIDES.

During the spring of 1912 the following experiments were conducted at Rocky Ford, Colo.

On April 8 several infested horse-radish plants were sprayed with the following mixture:

Paris green	pounds..	2
Whale-oil soap	do....	8
Water	gallons..	100

These plants were kept under close observation for several days, but no dead larvæ were found.

On April 29 several infested horse-radish plants were sprayed with the following mixture:

Arsenate of lead	pounds..	10
Whale-oil soap	do....	10
Water	gallons..	100

This experiment was likewise a failure and no larvæ were killed.

In these experiments the poisons were carefully and thoroughly applied. The surface and underside of the leaves, and in fact all portions of the plants above ground, were coated. This treatment, however, failed to kill the larvæ. This was due to the habit the larvæ have of resting and feeding under compact webs, where they are completely protected from stomach poisons.

RECOMMENDATIONS FOR CONTROL.

The experiments indicate that this insect can not be controlled with arsenicals. If artificial control measures should become necessary, much could doubtless be accomplished by burning the dead horse-radish leaves and petioles during the winter. After the dead leaves are removed the surface of the soil about the roots of the plants should be thoroughly stirred with a rake. This cultivation would crush or bury the hibernating larvæ which were resting in cracks in the soil.

CONCLUSION.

The investigation of this insect indicates that infestation is limited to a few horse-radish plants in one garden at Rocky Ford, Colo. In this garden the larvæ have evidently been prevented from causing much damage by a hymenopterous parasite, and at present no artificial control measures are necessary.

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